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TWO NEW ANTS FROM JAVA

BY GEORGE C. WHEELER AND ESTHER W. WHEELER

University of North Dakota

*Phaulomyrma*¹ new genus

♂ Head flattened, slightly emarginate behind. Eyes protruding, large (diameter about one-third the length of the head), and situated near the anterior border. Clypeus indistinct or large and somewhat convex. Antennæ 13-segmented. Thorax compressed. Legs slender; two spurs on the middle and hind tibiæ; metathoracic legs, long, extending beyond the tip of the abdomen. Wings hairy; fore wings large, with one or three reduced veins; the margins fringed with hairs; hind wings much smaller. Hairs abundant especially on the dorsum. Integument smooth or with scattered hairy punctures. Genitalia large and projecting. Sagittæ wide at the base. Subgenital plate bifurcated.

Type: *Phaulomyrma javana* new species.

This genus is to be distinguished from *Leptanilla* by the presence of wing veins and the unusually large genitalia.

It is our opinion that *Leptanilla tanit* Santschi should also be included in this genus.

Phaulomyrma javana new species

♂ Length—1.2 mm.

Head large, about one-fifth of the entire length, slightly longer than broad, somewhat narrowed behind; the posterior border emarginate.

¹ *Phaulos*, trifling, paltry + myrmex, ant.

Eyes large, diameter equal to one-third the length of head, prominent, hairy, hemispherical, situated very far forward. Ocelli oval, almost on the vertex.

Antennæ thirteen-jointed, half as long as the body; flattened; inserted on the anterior margin of the head;

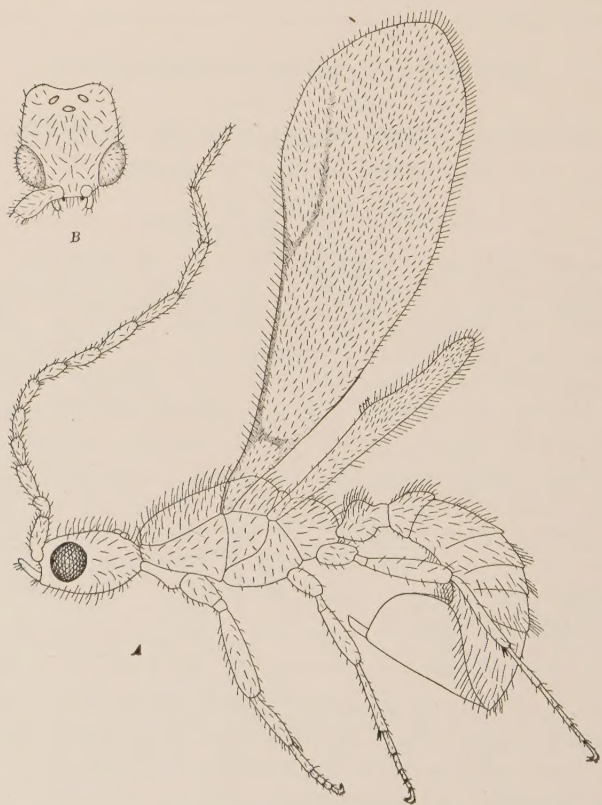


Fig. 1. A. *Phaulomyrma javana*, lateral view ♂. B. *Phaulomyrma javana*, front view of head.

twice as far apart as the distance from the eyes. First segment thickest, one-third as wide as long; second, one-half the length of the first, curved and thickened apically; third, as long as the first; fourth to the thirteenth gradu-

ally lengthening until the thirteenth is one-third longer than the first and one-half as wide.

Mandibles minute, labial palpi prominent, one-jointed. Frontal carinæ very short and indefinite. Clypeus indistinct.

Thorax at its maximum breadth two-thirds the width of the head, compressed into a somewhat cuneiform shape with the thin edge above. Sutures distinct. Pronotum concealed from above. Dorsal profile in lateral view ascending evenly and obliquely, forming an obtuse angle at the middle of the mesoscutellum, depressed at the sutures of the metanotum, which is rounded. Epinotum rounded.

Anterior leg thickened, spur one-half the length of the first tarsal joint; mesothoracic leg shorter and much more slender than the others; meso- and metathoracic tibiae each with two simple spurs. Hind leg reaching just beyond the tip of the abdomen.

Fore wing three times as long as its greatest width, which is at one-quarter of the length from the apex. Costal and radial veins present, also a cross-vein near the base. Stigma poorly defined. Hind wing very narrow, eight times as long as its greatest width (just beyond the middle) and one-half the length of the fore wing.

Abdomen as wide as the head, one-half the length of the entire insect, and strongly curved so that the sagittæ extend forward to the base of the abdomen. Petiole convex below, attenuated anteriorly; posterior third subcylindrical. Node hemispherical.

Hairs abundant except on the genital capsule which is naked; longer on mouth parts and front, and longest on the dorsum of thorax, apex of node, and dorsal tufts on each abdominal segment; more sparse and half as long ventrally. Eyes with numerous very short hairs. Wings conspicuously hairy; the hairs on the surface short, those fringing the margin much longer, decreasing in length toward the base.

Color ferrugino-testaceous, antennæ lighter. Legs and mouth-parts light yellowish brown. Integument smooth.

Genitalia large and non-retractile. Lamina annularis slightly compressed. Sagittæ widened at the base, the apex extending beyond the stipites; the latter hairy, acuminate, slightly curved, and folded within the lamina annularis.

Volsellæ thin, plate-like, with broadly rounded free margins. The prongs of the bifurcated subgenital lamina slender, one-fourth as long as the genitalia.

Described from two males from Buitenzorg, Java (III-'07), collected by F. Muir. (Ex. coll. W. M. Wheeler.)

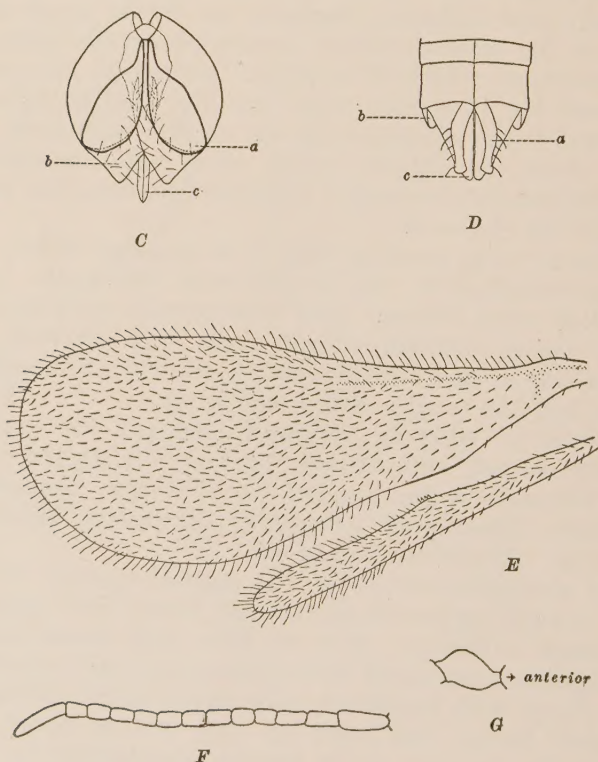


Fig. 2. C. *Phaulomyrma javana*, ventral view of male genitalia. a, Volsellæ; b, Stipites; c, Sagittæ. D. *Leptanilla santschii*, ventral view of male genitalia. E. *Leptanilla santschii*, wings. F. *Leptanilla santschii*, antenna. G. *Leptanilla santschii*, right lateral view of petiole.

Leptanilla santschii new species

♂ Length—1.2 mm.

Head large, about one-sixth the entire length of the body, one and four-fifths times as long as wide, somewhat narrowed behind.

Eyes large, protruding, diameter about one-third the length of the head, situated far forward, hairy, posterior margin slightly emarginate. Median ocellus oval, the others rounded and placed near the vertex.

Antennæ thirteen-jointed, little more than one-half the length of the body. Insertions twice as far apart as the distance from the eye, and situated close to the mouth. First segment almost one-third as wide as long; second and third each, nearly one-half the length of the first; fourth to twelfth, one-third longer than wide; last joint, slightly longer than the first and about one-half as wide.

Mandibles minute. Palpi prominent, single jointed. Frontal carinæ and clypeus indistinct.

Thorax compressed laterally, thinner above than below, depressed at mesoscutellum; measuring one-third the entire length of the body, one-half again as long as deep, four-fifths as wide in dorsal view as the head. Epinotum rounded.

Anterior legs very thick; mesothoracic legs shorter and more slender than the others. Femora thick. Mesothoracic tibia with one spur, metathoracic with two. Hind legs extending beyond the end of the abdomen.

Fore wing two and one-half times as long as its greatest width, which is at one-third the length from the apex. Costal vein and a cross-vein near the base very faintly suggested.

Hind wing ten times as long as its greatest width, which is near the middle, and two-thirds as long as the fore wing.

Abdomen one-third the length of the body and two-thirds the width of the head, rather straight to the sixth segment, which turns downward abruptly, so that the genitalia are at right angles to the rest of the abdomen. Genitalia one-sixth the length of the body. Node one and one-half times as long as high. Pedicel very short.

Genitalia conspicuous and probably non-retractile. Sagittæ rather thick, bent forward at the tip, slightly longer

than the volsellæ which are curved, slender with knob-like apices and several long hairs. Stipites short, broad, and blunt, less than one-half as long as the sagittæ.

Hairs abundant, longer on mouth parts, front, dorsa of the thorax, node, and abdomen; longest on the sixth abdominal segment; shorter on the antennæ; sparser and much shorter ventrally. Eyes with many, very short hairs. Wings conspicuously hairy; the surface hairs short; those fringing the margin twice as long. Genitalia naked, except the volsellæ.

Color ferrugino-testaceous; legs, genitalia, and mouth-parts lighter.

Integument smooth.

Described from a single male from Buitenzorg, Java. (Ex coll. W. M. Wheeler.)

In his "Social Life Among the Insects"² (p. 335) Dr. W. M. Wheeler has suggested that the Tribe Leptanillini would have to be removed from the Dorylinæ and raised to the rank of a subfamily. The senior author³, in his study of the larva of *Leptanilla revelierei sardoa* Emery, has supported this view.

The Leptanillinae resemble the Dorylinae in the following characteristics. The frontal carinæ are close together and do not cover the antennal insertions; the petiole consists of two segments in the worker, one in the male and female. A sting is present. The female is wingless; the thoracic sutures are more or less vestigial. In the male the subgenital lamina is usually bifurcate; cerci are absent. The tibiæ have spurs, which are sometimes rudimentary. The larva resembles the known doryline larvæ in the shape of the body, which is elongate, slender, subcylindrical, orthocephalic, and nearly straight, and in the small feebly chitinized mandibles.

In contrast, the following characters of the Leptanillinae differentiate them from the Dorylinae. The workers are monomorphic and minute; the maxillary palpi are one-jointed; the antennæ are always 12-segmented. The lobed hypopygium of the female extends beyond the pygidium.

² New York: Harcourt, Brace & Co. 1923.

³ Psyche 35:85-91, 1928.

In the male the mandibles are very short and have rounded points; the fore wings have few veins or more commonly none at all; the hind wings are veinless; the genitalia are non-retractile. The larva differs in the constriction of the body at the first abdominal segment; the absence of hairs on the head; and the presence of long hairs on the abdomen, especially the extremely long pair at the posterior end. But these differences become trivial and insignificant beside three characteristics which not only separate it from doryline larvæ but render it unique among all the known ant larvæ, namely, the plowshare-like structure projecting from ventral side of the prothorax, a "tympanum" on either side of the fourth abdominal segment, and the toothed flaps at either side of the labrum.

We offer the following as a formal definition of the subfamily:

Subfamily *Leptanillinæ* (W. M. Wheeler) (1910)

♀ Hypogæic, monomorphic, minute. Clypeus with a straight border, sometimes with two lobes prolonged between frontal carinæ, which are short. No carinæ on cheeks. Mandibles straight and toothed. Maxillary and labial palpi each with one segment. Eyes absent. Antennæ 12-jointed, inserted farther apart than in the Dorylinæ and having a filiform funiculus. Promesonotal suture marked, other dorsal sutures completely absent. Epinotum unarmed. Tibiæ with a pectinate spur. Claws simple. Petiole of two segments, both nodiform and of almost the same size. Gaster elongate, oval. Pygidium simple.

♀ Head and thorax like that of the worker. The suture behind the anterior legs fading out dorsally. Wingless. Postpetiole not separated from the following segment by a constriction. Gaster long; cloaca open leaving the sting exposed. Hypopygium longer than the pygidium, with two lateral lobes bent back dorsally.

♂ Head large, more or less rectangular. Clypeus and frontal carinæ somewhat as in worker or indistinct. Mandibles very short, small, rounded, and toothless. Maxillary and labial palpi prominent, one-jointed. Eyes conspicuous, hairy. Antennæ 13-segmented. Scape nearly or quite as long as the next two segments together. Funiculus filiform,

terminal segment long. Mesothoracic tibiae with one or two simple spurs, metathoracic with two. Fore wings with few or no veins; stigma never well defined; hind wings veinless. Petiole one-jointed. Genitalia large, non-retractile; subgenital plate bifurcate.

Subfamily *Leptanillinæ* (W. M. Wheeler)⁴

Genus *Lepantilla* Emery⁵

Leptanilla Emery, 1870, ♀, Bull. Soc. Ent. Ital. 2:196. Emery, 1904, ♀, Arch. Zool. 2:107. Santschi, 1907, ♂, Rev. Suisse Zool. 15:305.

Leptanilla butteli Forel, 1913, ♀ Zool. Jahrsb. 36:25. Federated Malay States: Selangor.

Leptanilla doderoi Emery, 1915, ♀, Ann. Mus. Civ. Stor. Nat. Genova 46:253, pl. 4, fig. 3, 4. Emery, 1916, ♀, Bull. Soc. Ent. Ital. 47:96, Sardinia: Teulada.

Leptanilla exigua Santschi, 1908, ♂, Ann. Soc. Ent. France 77:519, fig. 1, 3. Emery, 1910, ♂, Gen. Insect. p. 33. Tunis: Kairouan.

Leptanilla havilandi Forel, 1901, ♀, Ann. Ent. Soc. Belg. 45:373. Emery, 1910, ♀, Gen. Insect. p. 33. Singapore.

Leptanilla minuscula Santschi, 1907, ♂, Rev. Suisse Zool. 15:309, fig. 3. Santschi, 1908, ♂, Ann. Soc. Ent. France 77:520, fig. 2. Emery, 1910, ♂, Gen. Insect. p. 33. Tunis: Kairouan.

*Leptanilla nana*⁶ Santschi, 1915, ♀, Bull. Soc. Hist. Nat. Afr. Nord. (7me année) 6:55-57, fig. 2. Tunis: Kairouan.

⁴We have not included here the Genus *Leptanilloides* Mann (Psyche 30:13-14, 1923), because the sexual forms are unknown. To quote Mann (p. 15)—

"In general habitus this [*Leptanilloides*] is very similar to *Leptanilla*, but the structure of the head associates it more closely with *Eciton*, from which it is distinct in the form of the frontal lamellæ, the form of the gaster and in not being polymorphic."

⁵*Leptanilla nordenskioldi* Holmgren (Zool. Anzeiger 33:347) is an *Eciton* (*Acamatus*) according to Emery (Gen. Insect. p. 25, 1910).

⁶Santschi says in this paper, "*Le ♂ du Lep. minuscula* Sant. dont la tête est également très allongée, provient des mêmes terrains et pourrait bien être celui du *L. nana*."

Leptanilla santschii, new species. Java: Buitenzorg.

Leptanilla revelierei Emery, 1870, ♂, ♀, Bull. Soc. Ent. Ital. 2:196, pl. 2, fig. 2, 7. Emery, 1876, ♂, ♀, Stettin, Ent. Zeitg. 37:74. Ern. André, 1882, ♂, ♀, Spec. Hym. Eur. 2:269, pl. 16, fig. 4, pl. 17, fig. 1. Dalla Torre, 1893, ♂, ♀, Cat. Hym. p. 72. Emery, 1904, ♀, Arch. Zool. 2:108, fig. 1-4. Emery, 1910, ♂, ♀, Gen. Insect. p. 33, fig. 8. Emery, 1916, ♂, ♀, Bull. Soc. Ent. Ital. 47:96, fig. 8, 9. Corsica: Corte. Sardinia.

Leptanilla revelierei var. *bimaculata* Emery, 1899, ♂, Bull. Soc. Ent. France p. 20, fig. Emery, 1910, ♂, Gen. Insect. p. 33. Emery 1916, ♂, Bull. Soc. Ent. Ital. 47:96. Corsica.

Leptanilla revelierei subsp. *chobauti* Emery, 1899, ♂, Bull. Soc. Ent. France, p. 20. Morocco: Tangier.

Leptanilla revelierei subsp. *sardoa* Emery, 1916, ♂, Bull. Soc. Ent. Ital. 47:97. G. Wheeler, 1928, larva, Psyche 35: 85-87, fig. Sardinia: Carloforte.

Leptanilla tenuis Santschi, 1907, ♂, Rev. Suisse Zool. 15:307, fig. 1. Emery, 1910, ♂, Gen. Insect. p. 33. Tunis: Kairouan.

Leptanilla theryi Forel, 1903, ♂, Ann. Soc. Ent. Belg. 47:252. Emery, 1904, ♂, Arch. Zool. 2:110, fig. 5, 6. Emery, 1910, ♂, Gen. Insect. p. 33, pl. fig. 8. Santschi, 1915, ♀, Bull. Soc. Hist. Nat. Afr. Nord 6:57-58, fig. 3. Eastern Algeria. Tunis: Sousse.

Leptanilla vaucheri Emery, 1899, ♂, Bull. Soc. Ent. France, p. 19, fig. Emery, 1910, ♂, Gen. Insect. p. 33. Morocco: Tangier.

Genus *Phaulomyrma* new genus

Phaulomyrma javana, new species. Java: Buitenzorg.

Phaulomyrma tanit Santschi (= *Leptanilla tanit* Santschi), 1907, ♂, Rev. Suisse Zool. 15:310, fig. 2. Emery, 1910, ♂, Gen. Insect. p. 33. Tunis: Kairouan.

THORACIC MODIFICATIONS ACCOMPANYING THE
DEVELOPMENT OF SUBAPTERY AND APTERY
IN THE GENUS *MONOMORIUM*¹

BY GEORGE S. TULLOCH.

The occasional appearance of forms intermediate between the alate and the apterous castes of the Formicidæ offers some ontological evidence of early stages in the origin of castes and has an important bearing on the question of development of organic forms through continuous or saltatory variation. The differentiation into castes is a condition which has existed for a long period of time since it is clearly shown in the many beautifully preserved ants of the Baltic amber from the Lower Oligocene Tertiary.

In several genera of ants it is possible to trace all the transitional stages in the thoracic structure from that of the winged female to the wingless worker, except that the wings show no transitions, being perfectly developed in the typical female and entirely lacking in all the other forms of the series. In two genera gradational changes in the wing structure have been figured, one in the genus *Monomorium* (Wheeler, 17) and the other in the genus *Pogonomyrmex* (Tulloch, 30). The series of *P. californicus* which was given to the writer by Professor Harlow Shapley of the Harvard College Observatory exhibited various transitional stages of the wing from the completely venated type to a veinless wing sac. However, the appearance of these forms was considered to be pathological (since they only occurred in one colony) and, therefore, are perhaps not as instructive as the case noted by Dr. Wheeler in the genus *Monomorium*. Here it was discovered that at least two species exhibited a normal and unsuspected condition of subaptery in the female.

¹ Contribution from the Entomological Laboratory of Harvard University, No. 336.

Before proceeding to the description of this condition of subaptery, it should be noted that an extremely unusual condition of aptery has long been recognized in *Monomorium*. In *Monomorium floricola*, *M. carbonarium* subsp. *ebeninum* and *M. minutum* subsp. *ergatogyna* Dr. Wheeler (1905) observed that the females had a thoracic structure typical of winged forms, yet they showed no indication of ever having borne wings. Thus we have a case of aptery unaccompanied by the usual fusion of sclerites and by huge diminution in size of the thorax. Forel describes *M. andrei* of Oran as having both winged and ergatoid females as well as the Indian *M. shurri* and *M. dichroum*, but as he fails to explain the thoracic structure of the ergatoid and the winged female, it is impossible to judge whether the apterous condition here is similar to the case cited by Dr. Wheeler.

In two Australian species, *M. rothsteini* and *M. (Notomyrmex) subapterum*, the males show no differences in the size and development of the wings, which in both species are large and of the usual structure, but the females exhibit differences in the size of the thorax and wings. The wing of *rothsteini* measures 6.8-7 mm., while that of *subapterum* is only 3 mm., and its thorax is also much reduced in size. A somewhat similar case was found in the female of the related species *M. (Notomyrmex) rubriceps*. In a specimen of an incompletely deälated female the size of the remaining hind wing indicated that all the wings were very much reduced previous to deälation, and probably represented a more advanced condition of subaptery than the female of *subapterum*. It should be noted that in the case of *subapterum* several specimens of the female were available for study, each exhibiting the subapterous condition of the wing. In the case of *rubriceps* only a single specimen of the female illustrates the subapterous condition, while in five other specimens from the same nest all the intermediate stages between the subapterous and the apterous condition are represented. In the case of *subapterum* the condition of subaptery is evidently normal, while in *rubriceps* it is, perhaps, abnormal. However, whatever the case may be, the female of *rubriceps* repre-

sents a new condition of subaptery which had been hitherto unknown until described by Dr. Wheeler.

The specimens of *M. rubriceps*, six in number, were found to contain an interesting series of intermediate forms between the subapterous condition represented by

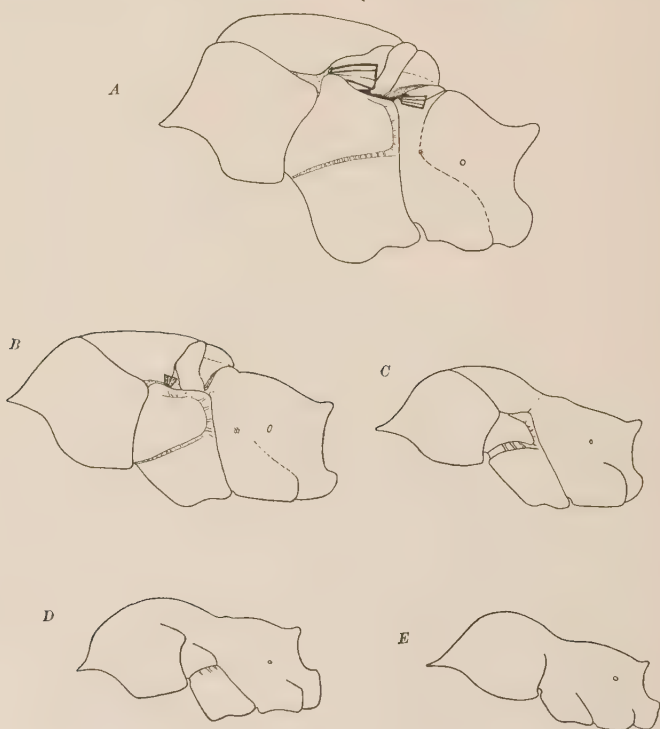


Fig. 1. Thoracic modifications in *Monomorium*.

the female mentioned above and the apterous condition exhibited by the worker. Dr. Wheeler first noted this series and figured the modifications existing in the notal regions of the thorax. Since the pleural regions exhibit various equally interesting morphological modifications from the winged to the apterous condition, and since they may represent phylogenetic stages in the origin of castes,

the following description is offered. The specimens examined are all from the collection of Dr. Wheeler, through whose kindness the writer is enabled to describe them.

The subapterous female of this particular species measures 6.5 mm., has well-developed ocelli, and its thorax (Fig. A), although somewhat reduced, is of the same general composition as its close relative, *M. subapterum*. The stumps of wings are present except on the hind right side, where the entire wing is retained. It is much reduced in size and may be considered as vestigial. The other wings have been lost by deâlation. The structure of the pleural region of the thorax is not unlike that of other Myrmicinæ, and since it is not the purpose of this paper to discuss the morphology of these forms, but rather to indicate the annectant stages between the alate and the apterous castes, a discussion of the different sclerites is omitted. The second stage (Fig. B) is one in which the hind wings have entirely disappeared, yet the stumps of the fore wings are present. The transition to this stage has been accompanied by a reduction in size of the thorax and by the fusion of the pleuron and notum in the regions formerly occupied by the hind wings. A further step in the series (Fig. C), indicated that the wings have totally disappeared, and the thorax has become greatly reduced in size. Fig. D represents another stage illustrating a simplification of structure and a reduction in size. Fig. E represents the true worker and is characterized by the presence of an enlarged pronotum, which appears to be a fairly constant character of the worker caste among most genera of Myrmicinæ.

The evidence derived from the series of *Pogonomyrmex* and this series of *Monomorium* may have an important bearing on the question of the production of organic forms through continuous or saltatory variation. The gradation of the intermediate forms is so continuous that one is almost forced to accept the explanation of the production of organic forms through continuous variation as the more logical of the two. The appearance of intermediate forms would seem to suggest at once that the origin of castes could not have come about as a saltatory variation or mutation. It is very possible that the explanation involving continuous variation may be incorrect, and one must turn to other

hypotheses to answer this question. When one considers the influence of nutritional factors upon the production of abnormal forms (especially among the arthropods), it is quite possible that the suggestion made by LaMeere (1909) considering nutritional factors as influencing the origin of castes among the ants may be of greater significance than has been hitherto suspected.

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1917. The Phylogenetic Development of Subapterous and Apterous Castes in the Formicidæ. Proc. Nat. Acad. of Sci., Vol. 3, pp. 109-117.

ANT-LIKE SPIDERS OF THE GENUS MYRMARACHNE FROM THE PHILIPPINES

BY NATHAN BANKS

In the collection of Arachnida of the Philippine Islands in the Museum of Comparative Zoölogy are a number of specimens of the interesting ant-like genus *Myrmarachne*. Peckham described four species and the types are here, Karsch described one, and Chamberlin one species. The large species, *M. maxillosus* Koch, known from various parts of the Malay region, also occurs in the collection.

In this paper I shall treat only of the males, believing that we know too little as yet to place the females properly; in several cases, however, there are females with males to which they evidently belong. I have, therefore, not treated of *M. edentulus* which Peckham based on a female; quite possibly it is the female of *M. bellicosus*. The specific characters are best illustrated in the jaws, their shape and armature. The male palpi are so nearly alike in the several species that it appears they are less useful than in most spiders; the case is similar to that of Tetragnatha.

The following synoptic table will distinguish the forms so far known; doubtless there will be fully as many more to be found in the islands. Only one of the species is from Mindanao, most of them from Luzon. Except *M. maxillosus* none of the species agree with the species known from Ceylon, Malacca, Java, or Borneo.

1. Two teeth on outer upper edge of each jaw, jaws not constricted, fang without tooth, lower outer edge of fang-groove with a row of small teeth *bidentata* 2
No teeth on outer upper edge of jaw.....
2. Inner upper edge of jaw with a prominent tooth before tip, and a large blunt tooth-like process at tip; jaws not constricted at base, abdomen not constricted, large dark species *maxillosus* 3
No tooth on upper inner edge of jaw before tip ...

3. The jaws (seen from side) more or less plainly constricted on basal part and swollen above on apical part 4
 The jaws (seen from side) not constricted on basal part, nor swollen on apical part, but even along the top 9
4. Abdomen very plainly constricted before middle; fang evenly curved, color yellowish throughout *assimilis*
 Abdomen not plainly constricted above, fang sinuous 5
5. On lower outer edge of fang-groove a row of distinct teeth to near base, fang with blunt tooth near middle, jaws not much swollen toward tip *opaca*
 On lower outer edge of fang-groove only a few small teeth, not noticeable except near tip, fang without tooth 6
6. Jaws only a little swollen toward tip, fang but slightly sinuous; no tooth missing on lower inner edge toward tip 7
 Jaws greatly swollen toward tip, fang plainly sinuous 8
7. Color mostly dark *bellicosus*
 Color wholly pale yellowish *dubius*
8. Jaws more suddenly swollen on basal side, no prominent teeth on outer fang-groove, head more globose than usual *tagalica*
 Jaws more gradually swollen on basal side, three prominent teeth near tip on outer fang-groove *mcgregori*
9. Abdomen not constricted above, but very slender, cephalothorax very long, but slightly cut back of eyes, no tooth on fang, color iridescent above *iridescens*
 Abdomen constricted above, and with two shields, plainly separated 10

10. Fang with one (or two) teeth..... 11
 Fang without tooth..... 12
11. Fang with one long, and one very short or indistinct tooth; teeth on lower inner edge large, cephalothorax only slightly indented back of eyes.....*chapmani*
 Fang with one short tooth; inner teeth on lower side small; cephalothorax deeply indented back of eyes *piercei*
12. Fang plainly sinuous; cephalothorax moderately indented, inner row of teeth even (not one missing), outer edge of fang-groove with row of distinct teeth *seriatis*
 Fang evenly curved, no row of distinct teeth along outer edge of fang-groove..... 13
13. On lower inner edge one tooth skipped, fang not constricted near tip, nor wrinkled, cephalothorax only slightly cut behind eyes, larger species*bakeri*
 On lower inner edge no tooth skipped, all at subequal distances apart, fang wrinkled beneath and constricted before tip, cephalothorax more deeply cut back of eyes, smaller species*nigella*

***Myrmarachne bidentata* sp. nov.**

Fig. 4

Cephalothorax dark red-brown, jaws red-brown, dorsal shield of abdomen dark red-brown, rest of abdomen brown; legs yellow-brown, tarsi 3 and 4 pale and coxæ 1 very pale. Cephalothorax but little indented back of eyes, only about the height of third eyes; eyes of second row as near third as to A. S. E. and higher up. Jaws heavy, shorter than the cephalothorax, seen from side convex above and below, sides transversely wrinkled from above rather broadest on apical third, outer edge with two prominent teeth, the apical one usually more blunt than the basal, the edge between sometime slightly concave, lower inner edge with a rather large apical tooth and about three before

it, outer edge of fang-groove with a faint carina and several teeth, two near tip longer and more visible from side; fang slightly sinuous, without tooth. Palpi about as long as jaws, the tibia a little shorter than tarsus. Legs of moderate length; femur swollen at base more than others, tibia 1 with six pairs of long spines. Sternum narrow, anterior coxæ nearly touching, second coxæ also swollen within. Abdomen not constricted, with one large dorsal shield, truncate before tip, and with little if any indication of a basal division.

Body.—Length 6-7 mm.

From Mt. Makeling (Baker), Malinao, Tayabas (Baker), and Sarai, Paete, Laguna (McGregor).

***Myrmarachne maxillosus* Koch**

Several specimens from Los Banos (Baker), Malinao, Tayabas (Baker). In one specimen the anterior tibia is short and with but four pairs of spines, others have the front tibia longer (though variable) and with more spines, but the characters of the jaws are the same in all.

***Myrmarachne assimilis* sp. nov.**

Figs. 7, 13.

Pale yellowish throughout, jaws rather darker, fang dark red-brown, except pale tip. Cephalothorax very deeply cut behind eyes, much more so than usual, thoracic part scarcely rising behind cut; eyes of second row near to and a little above the anterior laterals. Jaws longer than the cephalothorax, much constricted on basal half, so that narrowest part (seen from side of above) is about half of the widest part, a faint outer carina, and an inner one on apical part, transverse wrinkles rather faint except on inner sides; on inner lower edge five teeth at subequal distances apart on apical half, a few small ones on basal part, outer edge of fang-groove with ten or more teeth, two near tip rather larger than the others which are very small; fang gently evenly curved, not at all sinuous. Palpi with tibia a little longer than tarsus. Legs very slender, front femora but

little enlarged at base, tibia 1 with five outer and four inner spines. Sternum not very narrow, about as broad between coxæ 1 as between coxæ 2. Abdomen elongate, much constricted at basal third, with two separated shields, and showing some trace of dark marks.

Body.—Length 8 mm.

From Mt. Makeling (Baker) also females probably belonging thereto, and a female from Calayan Island, (McGregor).

It is related to *M. plataleoides* Peck. from Ceylon, but the swollen part of the jaw is longer, and the tibia of palpus though elongate is not as much so as in *M. plataleoides*.

***Myrmarachne opaca* Karsch**

Fig. 12.

Cephalothorax dark red-brown to black, the mandibles also; legs yellow brown to dark brown, often not marked; abdomen dark, nearly black. Cephalothorax quite deeply cut back of eyes, the thoracic part rising somewhat behind before sloping off to tip; eyes of second row plainly a little nearer to A. S. E. than to third row. Jaws fully as long or longer than the cephalothorax, constricted on basal half, but not as much so as in *tagalica* or *mcgregori*, about as much as in *M. bellicosus*, from above about one-half wider in widest place than at base, each edge with a carina, that on the inner side of apical part especially strong, on sides and above transversely wrinkled; lower inner edge with six or more teeth, those on apical part fairly large, but hardly at equal distances apart, lower outer edge of fang-groove marked with a long row of good-sized teeth, plainly visible from side all along to near the base; fang sinuous, and near middle with the beginning of a tooth. Palpi nearly as long as the jaws; the tibia about equal to tarsus; legs long and slender, the front tibia very long and with five pairs of spines; sternum moderately slender, plainly wider at coxa 2 than at coxa 1; abdomen rather short with one large shield above which on the anterior sides shows an indentation each side.

Body.—Length 6.5-7.5 mm.

From Manila, Los Banos (Baker); Culasi, Panay (McGregor); and Philippine Islands (J. W. Chapman). Karsch described it briefly from Samar; in 1912 I examined his type. This species is related to *M. turriiformis* Badcock, but the numerous teeth on outer edge of fang-groove separates it, the sternum is also narrower than the Malayan species. *M. robustus* Peck from Burmah is very close to *M. turriiformis*, and perhaps the same, but tibia of palpus a little longer.

The *M. tayabasanus* Chamb. (1925) appears to be this species; the type is not here, and the description gives nothing to show it distinct from *M. opaca*; the marks on legs vary.

Myrmarachne bellicosus Peck

Besides the type we have specimens from Serai, Paete, Laguna, (McGregor), and several marked only Luzon. The second femora usually shows a black line more or less plainly.

Myrmarachne dubius Peck

I have seen no more than the type, and doubt if it is distinct from *bellicosus*, the femur 2 shows a trace of the dark line. One of the *bellicosus* is paler than others but none approach *dubius* in the practically wholly yellow color. I fail to find anything different in the jaws; both forms have four pairs of spines under tibia 1.

Myrmarachne tagalica sp. nov.

Figs. 1, 10.

Cephalothorax reddish brown, almost black on top of head, jaws dull yellowish brown, legs yellowish brown, femora rather darker, abdomen nearly black above. Cephalothorax deeply cut behind eyes, and the side furrows also deep, behind cut rising slightly before sloping, cephalic part more globose than usual, the sides (seen from above) convex and hind corners well rounded. Jaws longer than cephalothorax, basal part much constricted, apical part

greatly swollen, and the swelling starts rather suddenly, each upper edge with a carina, lower inner edge with four teeth in apical part and some small ones on basal part, outer edge of fang-groove marked by a row of small teeth, those near tip scarcely larger and not noticeable from side; fang sinuous, no tooth. Palpi short, tibia hardly as long as tarsus. Sternum not very narrow, at coxæ 1 fully one-half as wide as at coxæ 2. Legs long and slender, tibia 1 fully two-thirds as long as jaw, with four pairs of spines, and an extra one near tip. Abdomen short, not constricted, rounded above, the two shields practically united.

Body.—Length 4.5 mm.

From Butuan, Mindanao (Baker).

***Myrmarachne mcgregori* sp. nov.**

Figs. 9, 14.

Cephalothorax red brown, clothed with appressed white hair, eyes on black spots, jaws dark red brown, legs pale yellowish brown, front pair rather darker, palpus mostly pale, abdomen black above, paler beneath. Cephalothorax deeply cut behind eyes, and the side furrows also deep, thoracic part sloping behind; eyes of second row a little nearer to A. S. E. than to third row. Jaws much longer than cephalothorax, very large, basal part constricted, apical part much swollen, but the slope rather gradual, from above not twice as broad as at base, lower inner edge with about five teeth, outer edge of fang-groove marked by a row of teeth of which several near the tip are larger and noticeable from side; fang strongly sinuous, no tooth. Palpi much shorter than jaws, tibia 1 not two-thirds as long as jaw, with four pairs of spines. Sternum narrow, not one-half as wide at coxæ 1 as at coxæ 2. Abdomen rather short, but little longer than the swollen part of jaw, evenly convex above, not constricted, but with two distinctly separated shields.

Body.—Length 3.2 mm.

From Sarai, Paete, Laguna (McGregor).

Myrmarachne chapmani sp. nov.

Figs. 6, 11.

Cephalothorax and jaws yellow-brown, black in front and around third eyes, legs yellowish; abdomen pale on basal half, beyond shining black, except extreme tip pale, anterior metatarsi slightly dark. Cephalothorax not deeply cut behind eyes, but side grooves are deep, and above the eye-region appears trilobed behind; eyes of second row about as near third row as to A. S. E. Jaws about as long as cephalothorax, straight, not constricted on basal part, from above the sides are nearly parallel, but outer somewhat convex, each edge with a carina; lower inner row of about seven large teeth, nearly evenly spaced, except near tip; outer edge of fang-groove not indicated and without teeth; fang long, scarcely sinuous, but with a very large tooth near basal third and the beginning of another near apical third. Palpi short, the tibia shorter than usual, no longer than broad. Legs short; femora, especially of leg 1, swollen at base, tibia 1 with four pairs of spines. Sternum much narrowed between coxæ 1, but moderately broad at coxæ 2. Abdomen elongate, constricted above, with two separate shields.

Body.—Length 4mm.

From Philippine Islands (J. W. Chapman), with ants.

Myrmarachne piercei sp. nov.

Fig. 2.

Cephalothorax with head black, thoracic part yellowish, base of abdomen pale, beyond dark, jaws red-brown, legs yellowish brown, metatarsi 1 dark, leg 2 pale, with a dark stripe in front of femur; leg 3 mostly brownish; leg 4 with coxæ, trochanters, and most of patellæ very pale, rest brown. Cephalothorax deeply cut back of the eyes, the thoracic part somewhat elevated behind cut; eyes of second row almost as near third row as to A. S. E. Jaws long, straight, hardly as long as the cephalothorax, not constricted above on basal part, upper edge with carina, outer side slightly convex, lower inner edge with only two or three small teeth toward tip, outer edge of fang-groove marked by a carina with a few small teeth scattered along

to near base; fang slightly sinuous with a distinct tooth near basal third and beyond that wrinkled within. Palpi much shorter than jaws, the tibia little longer than broad. Sternum quite narrow, but about as much widened between coxæ 1 and 2 as behind coxæ 2. Legs moderately short, tibia 1 with four pairs of spines, one beneath on patella 1. Abdomen rather long, plainly constricted above and on sides, and with two separate shields.

Body.—Length 6.5 mm.

From Victorias and Manapla, Occ. Negros (Pierce).

A female similar to male except short jaws may be the same species.

Myrmarachne seriatis sp. nov.

Fig. 5.

Cephalothorax nearly black, clothed with fine appressed white hair; jaws red-brown; legs mostly yellow-brown, femora often dark, front femur, tibia and metatarsus mostly dark brown; abdomen black, a pale band across between shields. Cephalothorax cut quite deeply back of eyes, but posterior face of head sloping; eyes of second row a little nearer to A. S. E. than to third eyes; jaws fully as long as the cephalothorax, heavy, very thick near base (seen from side), not constricted on basal part, from above outer edge convex, broadest a little beyond middle, each upper edge with a carina, above transversely wrinkled, lower inner edge with about four rather small teeth on apical part, besides the larger and sharp apical tooth, basal part with many small teeth, outer edge of fang-groove marked by a long row of teeth, plainly visible from side; fang sinuous, without tooth, the inner edge before middle somewhat wrinkled. Palpi short, tibia moderately short. Legs not very long, leg 1 short, tibia with five pairs of spines below. Sternum moderately slender, about as wide at coxæ 1 as at coxæ 2. Abdomen moderately short, but with two distinct dorsal shields, and slightly constricted between them.

Body.—Length 4.5-5.5 mm.

From Culasi, Panay (McGregor).

Myrmarachne bakeri sp. nov.

Fig. 8.

Cephalothorax brownish yellow, eyes on black band, jaws reddish brown, legs mostly dull yellowish, femora more brown, especially front ones, metatarsi 1 dark and a broad dark band on tibia 1. Abdomen dark, nearly black above, except tip, a pale band across between the shields. Cephalothorax only slightly cut behind eyes and then sloping off behind; eyes of second row about as near to the third row as to the A. S. E. Jaws longer than the cephalothorax, not constricted on basal part, the outer edge has a carina above and is plainly convex, a large tooth on inner edge near tip, one a little behind it, then a space equal to width of jaw before the next tooth followed by two more, and several very small, scattered teeth, not noticeable from sides; fang long, slender only slightly curved except at tip. Palpi much shorter than jaws, tibia about as long as tarsus. Legs fairly long and slender, tibia 1 with six pairs of spines beneath, one under the patella 1. Sternum not very slender, almost as wide at front coxæ as at coxæ 2. Abdomen rather short, broadest toward tip, only slightly constricted above and on the sides at basal third, but with two distinctly separated shields.

Body.—Length 5-6 mm.

From Mt. Makeling (Baker).

Myrmarachne iridescens sp. nov.

Fig. 3.

Cephalothorax iridescent bronzy black; jaws red-brown; legs pale, femur 1 and metatarsus 1 and outer half of tibia dark, hind tibia and metatarsus lineate with dark; abdomen black, above iridescent. Cephalothorax very long, cut only a trifle back of eyes, the thoracic part sloping gradually, and much longer than head; second eyes about half way between third and A. S. E.; jaws only about two-thirds as long as cephalothorax, not constricted at base, from above the outer side is convex, the broadest a little before middle, each edge with carina, surface transversely wrinkled above,

the inner edge produced in a sharp tooth, the lower inner edge with about five teeth, outer edge of fang-groove not marked by distinct teeth, fang but little curved. Palpi short, tibia shorter than tarsus. Legs slender, but rather short, femur 1 thick at base, tibia 1 with five pairs of spines below, patella with one spine. Sternum moderately narrow, a little narrower at coxæ 1 than at coxæ 2. Abdomen very long and slender, but not constricted above nor on sides, and with one long shield above.

Body.—Length 4.5 mm.

From Los Banos, Luzon, Phil. Islds. (Baker). The female with the males is similar in color and structure, except in having short mandibles.

Myrmarachne nigella Simon

Described by Peckham as *S. niger*, changed to *nigella* by Simon because *Salticus niger* was preoccupied. Besides the Peckham types we have it from Manila (Feb. 1917) and Dupax, Nueva Vizcaya, Luzon.

EXPLANATION OF PLATE 11.

- Fig. 1. *Myrmarachne tagalica*, jaw above.
- Fig. 2. *Myrmarachne piercei*, side.
- Fig. 3. *Myrmarachne iridescens*, side.
- Fig. 4. *Myrmarachne bidentata*, jaw above.
- Fig. 5. *Myrmarachne seriatilis*, side.
- Fig. 6. *Myrmarachne chapmani*, jaw above.
- Fig. 7. *Myrmarachne assimilis*, side.
- Fig. 8. *Myrmarachne bakeri*, jaw above.
- Fig. 9. *Myrmarachne mcgregori*, side.
- Fig. 10. *Myrmarachne tagalica*, side.
- Fig. 11. *Myrmarachne chapmani*, side.
- Fig. 12. *Myrmarachne opaca*, jaw above.
- Fig. 13. *Myrmarachne assimilis*, jaw above.
- Fig. 14. *Myrmarachne mcgregori*, jaw above and teeth near apex below.
- Fig. 15. *Myrmarachne opaca*, side.

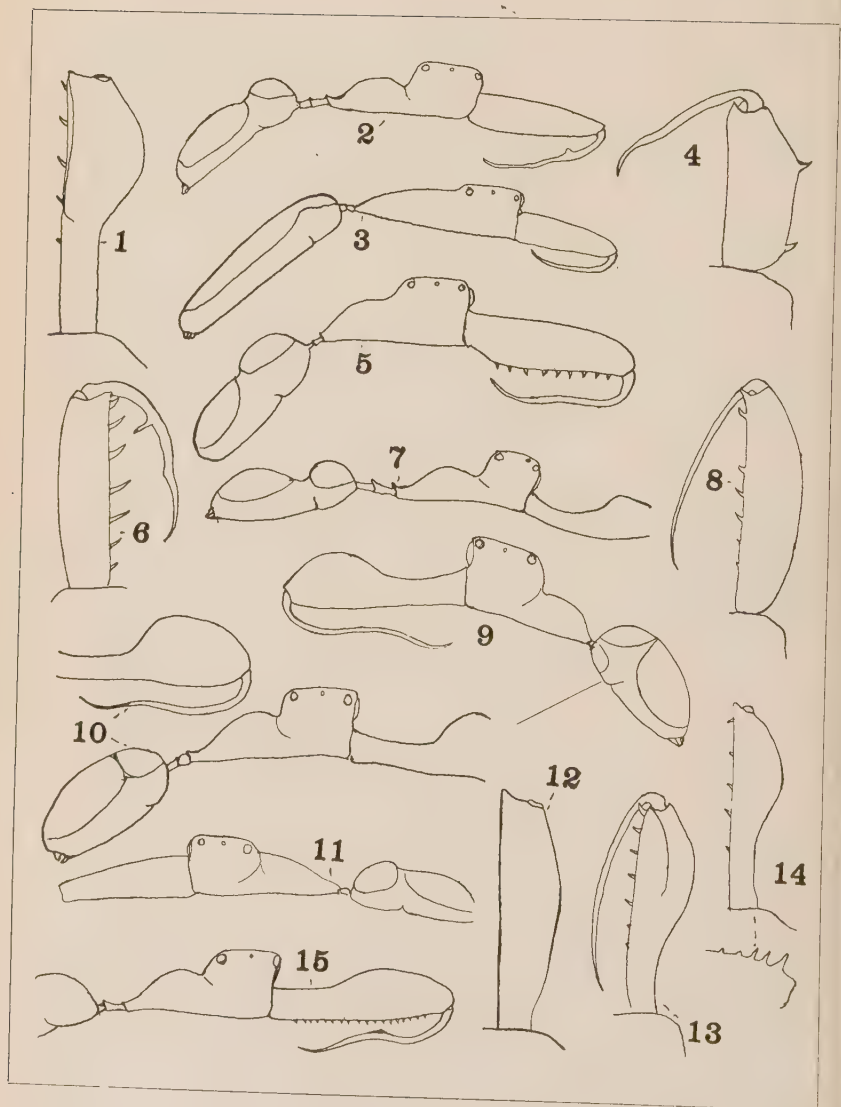


PLATE 11.

Banks, *Myrmarachne*.

A NEW BEE OF THE GENUS COLLETES
FROM PANAMA

BY MYRON HARMON SWENK

University of Nebraska, Lincoln, Neb.

In a lot of bees of the genus *Colletes* belonging to the British Museum, I found a well-marked new species, which may be described as follows:

***Colletes isthmicus* sp. nov.**

♀. Length 8 mm. Black. Head nearly one-third wider than long (57 x 75), the distance between the lower orbits only slightly (about one-tenth) less than the interorbital space on the vertex (42:38). Clypeus shining, convex with a median feebly sulcate area, coarsely striate-punctate except just before the apical margin which is smoothish, slightly reflexed and feebly medially emarginate. Supraclypeus shiny, coarsely and closely punctured except on a small, median, impunctate spot. Face dullish, densely and shallowly, rather finely punctured, the foveæ short and narrow, scarcely encroaching on the vertex, but the smooth, dullish internal portion crossing the depressed sides of the vertex as an impunctate band contiguous to the orbital summits. Vertex about ocelli shiny, finely and rather closely punctured, elevated. Cheeks shiny, sparsely indistinctly punctured, thinly clothed with simple, white hairs posteriorly. Malar space minutely lined, about one-third as long as wide or nearly that (3 x 10). Pubescence of face thin, very short, minutely plumose and grayish white in color, with longer, finely plumose, erect, sparse black hairs intermixed below the antennal level, the edges of the clypeus and supraclypeus with mixed black and yellowish, simple, suberect hairs, the clypeus nearly bare, its sparse hairs like those on its margins only shorter. Vertex with mixed black and whitish, thin, erect, plumose hairs, occiput

with a copious, white fringe. - Antennæ short, clavate, black with the under side of the flagellum slightly tinged with brownish, joint 3 slightly longer than 2 or 4, which are subequal, the proportion of joints 2-5 being 4.5:5:4.5:4.5, the median flagellar joints one-sixth shorter than wide (5 x 6). - Prothoracic spines very short but sharp, entirely concealed in the pubescence. Mesoscutum with rather coarse but not very deep punctures, separated the width of one or almost so anteriorly and laterally, on the posterior disk a distinctly defined, rather large, polished and impunctate area, the parapsidal furrows also bounded by impunctate lines. Mesoscutellum basally and medially polished and impunctate, laterally coarsely and rather closely punctured, the punctures crowded along the apical margin. Metanotum roughened by coarse, shallow, cancellate punctures. Superior face of the propodeum very broad and well defined, its apical margin strongly rimmed, divided by a few straight striæ into a few large, rectangular, shiny pits nearly as wide as long medially. Enclosure on the posterior face of the propodeum funnel-shaped, mostly smooth and polished, a few oblique striæ at extreme sides basally and indications of a short, basal median carina, the downward prolongation moderately broad at base. Surrounding areas of propodeum shiny, very coarsely reticulated. Mesopleura with coarse, round punctures about like those on mesoscutum anteriorly. Pubescence of mesopleura discally long, thin, erect, plumose and black, forming two longer and denser black tufts under and before the tegulæ, the space between these tufts with a contrasting, shorter, finely plumose, almost pollinose, snowy white hair-tuft, the mesoscutum with a short, plumose, mixed black and grayish white pubescence that is rather dense marginally but very thin discally, the pale hairs preponderating and forming an unmixed fringe along proscutal-mesoscutal suture, the mesoscutellum with copious, long, wholly black, plumose hairs with a contrasting snowy white axillary tuft of short hairs and a narrow fringe of similar hairs in the mesoscutal-mesoscutellar suture, the metanotum and propodeum with long, copious, erect, plumose, grayish white hairs, these very thinly mixed with dark ones on the sides of the posterior face of the propodeum. Tegulæ shining

piceous. Wings hyaline basally, slightly darkened on the apical margin and in the marginal cell, nervures and stigma dark brown, second submarginal cell above slightly wider than the third. Anterior coxæ simple. Tarsal claws red, deeply medially toothed. Tibial spurs dark, the anterior one finely pectinate. Hind basitarsi three times as long as wide (25 x 8). Hind legs with the coxæ, trochanters and inferior base of the femora whitish-haired, the femora above and at apex black-haired, the tibial hairs almost all black, especially the long-plumose hairs on the anterior face, the basitarsi with pale yellowish hair within but black bristles externally, the intermediate legs with mostly pale hairs but black-haired on tibiæ and basitarsi externally, the anterior legs pale-haired and with yellowish hair on the tarsi. Abdomen neatly conical, polished, basal tergite impunctate, tergite 2 minutely and indistinctly punctured. Apical margins of the tergites (1-5) broadly but feebly depressed and covered with a loose, minute pile to form broad, pale yellowish fasciæ. Basal tergite with very thin, erect, white hair, tergites 2 and 3 with a minute, thin, black pile, tergites 4-6 with a longer black pile and numerous long, black bristles. Venter finely, indistinctly punctured and minutely reticulated, sternite 6 toward apex finely rugose and with crescentic, shallow, lateral fossæ on each side of the median line.

♂. Length 6-7 mm. Distinctly smaller and more slender than the ♀. Head sub-triangular, about three-tenths wider than long (50 x 65) and the face narrowing about one-fourth between the vertex and the lower orbital margins (39:20). Sculpture of clypeus, supraclypeus and face as in the ♀, but pubescence longer and more copious with the black hairs below antennal level much more numerous and the pale ones tinged with yellowish. Depressed sides of the vertex impunctate or very feebly punctured, the elevated area very slightly black-haired. Malar space of the same length as in the ♀ but much less wide so that it is nearly one-half as long as wide (3 x 6.5). Antennæ long, slender, black with the flagellum obscurely brownish beneath, joint 3 shorter than 4 or following, the proportion of joints 2-5 being 3.5:5:6.5:7.5, the median flagellar joints about one and two-fifths as long as wide (7.5 x 5.5). Meso-

scutum and mesopleura much less coarsely punctured than in the ♀, and the punctures separated about twice the width of one, the mesoscutellum with the posterior punctures not crowded; otherwise the thoracic sculpture as in the ♀. Thoracic pubescence yellowish white, short and thin and very feebly intermixed with blackish on the mesoscutellum, mesoscutellar hairs long and mostly blackish, hair of metanotum, propodeum and mesopleura long and thin, the latter region with a few blackish hairs intermixed. Wings rather less darkened apically than in the ♀, otherwise similar. Tarsal claws sub-apically cleft, the apical tarsal joint sometimes reddish. Tibial spurs not obviously pectinate. Hind basitarsi proportioned as in the ♀ (21 x 7), the intermediate one about twice as long as wide (II=4.5 x 8.5). Hair of legs all pale. Abdomen elongate conical, polished, basal tergite minutely punctured, the punctures separated several times the width of one, following tergites very finely, indistinctly punctured. Apical margins of the tergites more distinctly depressed than in the ♀, the fasciæ whitish and on tergites 1-5. Pubescence of the tergum much as in the ♀. Apical margins of the sternites with a dense, narrow, apical fringe, longest laterally, forming distinct hair bands. Sternite 6 apically smooth and shining, slightly concave, medio-basally slightly elevated, without distinctive sculpture.

Type Locality—San Lorenzo, Chiriqui, Panama.

Type—A female collected by Mr. Champion. In the collection of the British Museum.

Allotype—A male from the type lot. In the collection of the British Museum.

Remarks—This species is easily recognizable by the black hair of the mesopleura and posterior legs, impunctate first tergite, short malar space and small size, in the ♀. It is closest, probably, to *C. mexicanus* Cresson. The above measurements are of the type and allotype.

Specimens Examined—Total number 9 (2 ♀ ♀, 7 ♂ ♂), from localities as follows: Panama: San Lorenzo, 9.

NEW NEUROPTEROID INSECTS FROM THE
UNITED STATES

BY NATHAN BANKS

The following notes include a synoptic table to the species of *Boriomyia* and the description of three new genera of Trichoptera. The new Psocidæ represents a genus new to our fauna, quite different from anything else in the country.

PSOCIDÆ

Deipnopsocus texanus sp. nov.

Figs. 1, 2.

Body yellowish to reddish brown, no distinct markings, head with sparse, short white hair, longer on the clypeus; legs pale yellowish brown, with some white hair, few bristles, front femora broad and compressed. Wings hyaline, surface with a few scattered, short, minute, rounded scales, several rows of them on margin all around wing, some of these more elongate and pointed; the veins and margin and near margin with long, stout bristles as in *D. speciophilus*; the venation very similar to that species, but three apical forks, not quite alike in the two wings, in one as figured, in the other with the three forks about equal in length, all about as long as the third fork in wing figured; the stem of cubital fork is more than twice as long as in the Peruvian species. In the hind wing the venation is very similar to the other species.

Length—1.2 mm.

From Brownsville, Texas.

HEMEROBIIDÆ

Boriomyia ultima sp. nov.

Face uniform polished dark brown; vertex pale, with a median brown dot; antennæ and palpi pale yellowish; pro-

notum pale, a broad, median brown stripe; rest of notum pale, side of the metanotum marked with brown; pleura mostly brown; legs pale yellow; abdomen dull yellowish. Wings hyaline; fore wings with several large brown spots, many irregular smaller marks, more or less forming oblique transverse bands, a row over each gradate series, the larger spots near middle, another row before the first gradate series, with the large spots behind, and a large spot over the cross-vein between medius and cubitus; veins pale, with scattered brown dots; margin interruptedly pale and brown. Hind wings pale; veins pale, a few gradate veins dark. Fore wings not very broad, four radial sectors, the fourth forked once before the cross-vein, no cross-vein between the first and second sectors near base.

Expanse 15 mm.

From Angora Peak, Tahoe, Calif. (Van Duzee.)

Synopsis of Species of Boriomyia of United States

1. No cross-vein between the last (third) radial sector and radius; one between first and second sectors near base; hind wings with tip and costal mark brown—subgenus—new *Allotomyia*, 2
 A cross-vein between last radial sector (either third or fourth) and the radius; hind wings without large brown marks 3
2. Gradate series marked with dark brown *speciosa*
 Gradate series not dark, but broad brown area before first gradates and beyond the second gradates .. *fidelis*
3. Face pale, with a few dark spots or dots..... 4
 Face uniform shining brown 6
4. A large brown spot at base of antennæ truncate below; three radial sectors, the third usually forked but once before the cross-vein 5
 No such spot, face with small dots; four radial sectors, or if three, the third forked twice before cross-vein *longipennis*

5. Fore wings with numerous brown bands across; pronotum with dark brown stripe each side .. *coloradensis*
Fore wing without such bands; pronotum not plainly marked *pretiosa*
6. A cross-vein between first and second radial sectors near base; wings heavily marked, usually four radial sectors or the third forked twice before the cross-vein 7
No cross-vein between first and second radial sectors near base; usually three radial sectors and the third usually forked but once before cross-vein 8
7. Margin of fore wings heavily marked; pronotum with dark brown stripe each side *longifrons*
Margin of fore wings scarcely marked; pronotum not plainly marked *transversa*
8. Wing surface evenly fumose; veins not spotted; three radial sectors *brunnea*
Wings not evenly fumose; veins dotted or spotted with dark 9
9. Pronotum pale, unmarked; wings with only a few gradates dark *schwarzi*
Pronotum with lateral or median brown stripe; wings plainly spotted or banded with dark 10
10. Pronotum with broad brown median stripe. Wings with large spots tending to form bands; no lateral stripes; four radial sectors *ultima*
Pronotum with brown side stripes; and often median line; usually three radial sectors 11
11. Fore wings marked all over with dark spots in form of oblique, wavy bands, wings not especially long..... *disjuncta*
Fore wings with large dark spots mostly near outer and hind-margin, middle area scarcely marked; wings more elongate than usual *posticata*

LIMNEPHILIDÆ

Limnephilus hageni sp. nov.

Figs. 7, 8, 9.

Yellowish; thoracic notum brown, abdomen dull yellowish, to pale brown; legs pale, spines black, but several on front tibiæ yellow, hairs yellowish; wings yellowish, fore wing with posterior portion mostly yellowish brown, broken near middle by broad, oblique, pale area, a large brown spot near tip, and stigma mostly dark, the outer part of fourth and fifth apical cells and the first and second subapicals hyaline, base of apical cells and area before anastomosis also white hyaline, the brown contains but few pale spots.

Male genitalia related to *L. sansoni*, but the superior appendages smaller, the teeth on inner side differently arranged, the intermediate appendages black only at tip, somewhat curved, the lower appendages stouter and shorter. The female has two slender appendages very similar to those of *L. sansoni*. The species is quite a little smaller than *L. sansoni*.

Expanse 24 mm.

From Ft. Resolution, Great Slave Lake (Kennicott, 1862), Hagen had this by label of *sublunatus*, but the species Provancher sent Hagen as *sublunatus* is very different, the same as I described as *L. macgillivrayi*.

Limnephilus roberti sp. nov.

Figs. 10, 11, 12.

Yellowish, head with yellow hair, basal joint of antennæ with some black hair in front; thorax mostly with yellowish hair, but some dark ones on pronotum; abdomen more brown; legs pale yellowish, spines black, in the male the front tarsi are very long. Maxillary palpi of male with second and third joints subequal, in female the fifth is longest, plainly longer than third, the fourth somewhat shorter than second.

Wings yellowish, with fine yellowish hair, venation partly pale, many veins especially near lower apex, margined with

yellowish brown spots and patches, anal margin brown, with a few pale spots, a white mark on thyridium, just before the posterior anastomosis. Fore wings rather narrow, elongate, discal cell a little longer than pedicel.

Male genitalia have very short processes, the superior lobes are very pale, and not toothed, nor darkened within. In the female the superior plate has lateral spurs and a broad median lobe which is blackened beneath on the sides.

Expanse 20 to 22 mm.

From Winnipeg Lake (Robt. Kennicott).

***Limnephilus sackeni* sp. nov.**

Fig. 6.

Yellowish, abdomen more dull brown, spines on legs black, but a few inner ones near base of front tibiæ are yellowish; hair yellowish, some black on sides of face and under antennæ. Wings yellowish, fore wing with brown marks on plan of others of this section, the anal margin brown, streak through middle of wing, broken by the oblique hyaline spot beyond middle, region before and beyond anastomosis hyaline, surrounded with brown, which extends above to tip and below to the outer angle, stigma dark. Legs very slender, basal joint of tarsus of front legs about one-half of the tibia, but it is not equal to second plus third joint.

Male genitalia has the superior appendages rather long, reaching beyond lower appendages which are slender, the intermediate appendages are curved and much more slender than usual.

Expanse 31 mm.

From Sault de Ste. Marie River, 8 Sept. (O. Sacken.)

***Acronopsyche* gen. nov.**

Legs slender; no spines on under side of last joint of hind tarsi; spurs 1, 3, 3,; tibia of front pair with a few spines. Basal joint of antennæ moderately elongate, beyond barely crenulate; a group of two or three macro-

chætæ behind each ocellus. Pronotum very small. Wings very hairy, not granulate, discal cell of fore wings extremely long, fully four times as long as pedicel; radius bent at stigma, all apical cells fairly broad at base, first fork scarcely reaches back on discal cell; cubitus disjointed at posterior anastomosis, anal cell divided as usual. In hind wing the discal cell is also elongate, and the apical cells fairly broad near base. In the male the inner spur of the hind tibia is elongate, very attenuate, about twice as long as the outer spur.

Type A. *pilosa*.

In general appearance and structure related to *Ecclisomyia*, but the spur formula and short first fork separate it. It can be included in my table (Can. Ent. 1916, p. 121) by the following modifications.

- | | | |
|------|--|---------------------|
| 29. | At least one ocellar macrochætæ present..... | 30 |
| | No ocellar macrochætæ | 31 |
| 30. | Anal cell not divided; radius bent at the stigma,
spurs 1, 3, 3 | <i>Hylepsyche</i> |
| | Anal cell divided as usual | 30a |
| 30a. | Spurs 1, 2, 4, first fork long distance back on discal
cell | <i>Ecclisomyia</i> |
| | Spurs 1, 3, 3, first fork scarcely back on discal
cell | <i>Acronopsyche</i> |
| 31. | Spurs 1, 3, 3, equal to No. 31 of table. | |
| | Spurs 1, 2, 2, membrane granulate—equal to No. 36
of table. | |
| | Spurs 1, 3, 4, equal to No. 33 of table. | |

Acronopsyche pilosa sp. nov.

Fig. 13.

Brown; face and rest of head with pale hair, black hair on sides of face and between antennæ, vertex with yellow hair. Basal joint of antennæ brown, with pale hair,

beyond yellowish; in male the second and third joints of maxillary palpi subequal, in female the third joint is plainly longer than either the fourth or fifth; thorax with yellowish hair, abdomen pale on under side; legs pale, spines black, no spines on basal half of hind tibia, inner spur of male attenuate and elongate, about twice the outer spur. Wings very hairy, with long fringes, fore wings rather elongate, more or less irrorate with pale yellowish, and with spots on margin between tips of some of the veins, the hair between veins being largely pale, anastomosis especially behind broadly dark, stigma not especially marked, no hyaline dot on thyridium. Genital parts short.

Expanse 22 mm.

Modoc Co., California, 20 July. (Lindsey.)

SERICOSTOMATIDÆ

Neothremma gen. nov.

A Sericostomatid; the maxillary palpi of the male recurved, short, last joint with a long dense fringe on lower inner side; basal joint of antennæ elongate; ocelli present, but rather small, spurs 1, 3, 4. Venation fairly regular in both sexes, in general similar to that of *Silo*; the discal cell long, forks 1 and 2 back on discal cell, forks 3 and 5 also present; in the hind wing forks 1, 2 and 5 present, and the discal cell closed. Eyes not hairy.

Type *N. alicia* n. sp.

Includes apparently also *Thremma deceptiva* Bks.

Distinct from *Thremma* by shape of maxillary palpi of the male, and the presence of fork 1 in hind wings. From *Silo* to which it is possibly more related, it is separated by the ocelli, and but three spurs on middle tibiæ.

Neothremma alicia sp. nov.

Figs. 4, 5.

Pale brownish; clothed with mostly pale yellowish hair; fringe on last joint of male maxillary palpus black; yellowish hair on basal joint of antennæ, and in the male

a tuft of long curved hairs near the inner tip. Legs pale, spurs pale; male genitalia yellowish; a long slender median piece bent downward beyond middle, really of two appressed pieces as tip is seen from behind to be of two parts, a pair of slender nearly straight intermediate appendages, and a large ventral piece, hairy, its tip reaching the other parts. Wings with fine yellowish hair, stigma a little darker; first fork reaching back nearly to middle of discal cell, fork 2 only a little back on discal cell, fork 3 as far back as fork 2, tenth apical cell very short.

Expanse 13 mm.

From Tolland, Colorado (G. S. Dodds).

Similar to *N. deceptiva* which was based on a female; it differs in having the first fork reaching further back on a shorter discal cell, and in that the tenth apical cell is much shorter.

HYDROPSYCHIDÆ

Dolophiliella gen. nov.

Closely related to *Dolophilus*, having ocelli, palpi, vertex, spur formula, hairy hind tibia, and general shape of male appendages as in that genus. The venation is the same, except that fork 1 is lacking in both front and hind wings. In 1909 Ulmer described a new genus, *Dolophiloides*, for a form from Central Asia in which fork 1 was absent from the hind wings. This species has gone a step further in dropping that fork in the fore wings. It might be better to consider both this and *Dolophiloides* as subgenera of *Dolophilus*.

Type *D. gabriella*.

Dolophiliella gabriella sp. nov.

Fig. 14.

Yellowish; joints of antennæ marked with brown; palpi dark brown; vertex and pronotum with pale yellowish hair; legs yellowish, hind tibia of male with much long hair

behind. Wings with rather brighter yellow hair, without markings, fringe mostly gray; hind wings with mostly gray hair; a hyaline white spot behind end of discal cell in the fore wing. The discal cell is fully as long as its pedicel, fork 2 reaches to cell, forks 3 and 4 pedicellate, fork 3 with a pedicel twice as long as that to fork 4. In hind wings discal cell less than one-half the length of the third apical cell, fork 3 long pedicellate. The male genitalia has a broad, median nearly truncate projection from below; the lower appendages have the second joint nearly three times as long as the first, and enlarged at tip.

Expanse 12 mm.

From the San Gabriel Mts., Calif., June. (Grinnell.)

Nyctiophylax marginalis sp. nov.

Fig. 15.

Brown, head with pale yellowish hair, palpi brown, antennæ pale yellowish, pronotum with pale hair in the middle and brown on the margins, legs very pale, front tibiæ on outer side dark. Fore wings brown, clothed with brown and yellowish or golden hair, paler than in *N. vestitus*, around the outer margin are about eight to ten pale spots, between them the margin is darker; sometimes some of the spots are faint; hind wings brownish, with fine yellow hair, the fringe gray. In shape the wings are hardly as broad at stigma as in *N. vestitus*, the venation about the same as in that species.

Expanse 13 mm.

From Put-in-Bay, Ohio. (G. Townsend.)

Plectrocnemia pallescens sp. nov.

Fig. 3.

Pale yellowish throughout and clothed with pale yellowish hair; hair of fore wings very short, appressed, and almost golden; veins pale, sometimes tips of apical veins darker, with a dark spot on margin, pale dot between each pair, a

hyaline white streak on the median vein at fork and on cross-vein just beyond and on the cross-vein from median before the second apical fork; fringe wholly pale. Venation normal, discal cell long, four or five times as long as broad, fork 1 more than one-half of its pedicel (♂) or one-third of pedicel (♀); fork 3 plainly pedicellate, fork 4 before cross-vein; in the hind wings fork 1 is very short, fork 3 present in the female, not in male.

Expanse 13 to 15 mm.

From Put-in-Bay, Ohio, August (G. Townsend); also St. Anthony Park, Minn. (Lugger.)

EXPLANATION OF PLATE 12.

- Fig. 1. *Deipnopsocus texanus*, fore wing.
- Fig. 2. *Deipnopsocus texanus*, hind wing, scales.
- Fig. 3. *Plectrocnemia pallescens*, genitalia.
- Fig. 4. *Neothremma alicia*, head and antenna.
- Fig. 5. *Neothremma alicia*, genitalia.
- Fig. 6. *Limnephilus sackeni*, genitalia, side.
- Fig. 7. *Limnephilus hageni*, genitalia, side.
- Fig. 8. *Limnephilus hageni*, female, above.
- Fig. 9. *Limnephilus hageni*, male, above.
- Fig. 10. *Limnephilus roberti*, male, above.
- Fig. 11. *Limnephilus roberti*, female, above.
- Fig. 12. *Limnephilus roberti*, genitalia, side.
- Fig. 13. *Acronopsyche pilosa*, genitalia, side.
- Fig. 14. *Dolophiliella gabriella*, genitalia, side.
- Fig. 15. *Nyctiophylax marginalis*, genitalia, side.

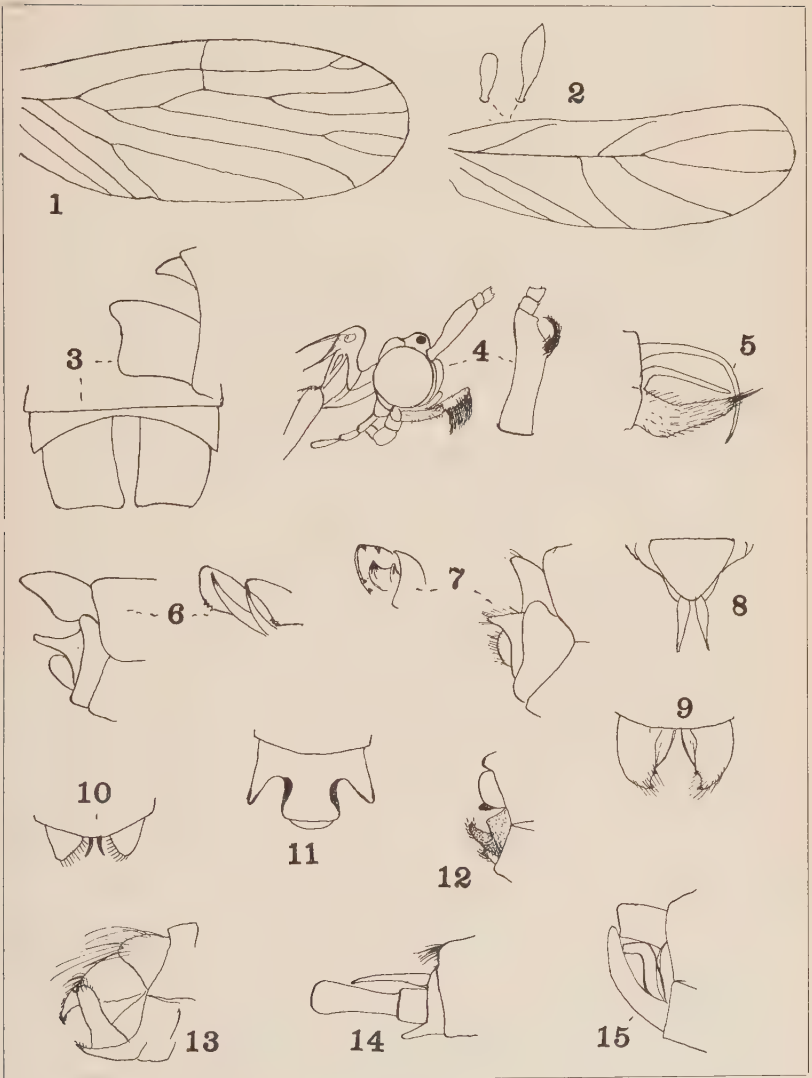


PLATE 12.

Banks—Neuropteroid Insects.

A KEY TO THE BITING MOSQUITOES OF NEW ENGLAND*

BY GEORGE S. TULLOCH

A study of the infestation and distribution of biting mosquitoes in Massachusetts was made during the spring and summer of 1930. To facilitate the identification of the mosquitoes found, the following key¹ was constructed; it being taken from Dyar² and Matheson³ and modified to include those species known to occur to New England. It is accompanied by a plate illustrating many of the taxonomic characters used in identification and by a few notes concerning mosquitoes considered to be of interest.

TABLE OF GENERA

Adults

- | | |
|---|-------------------|
| 1. Metanotum with a tuft of setæ | <i>Wyeomyia</i> |
| Metanotum without a tuft of setæ | 2 |
| 2. Wings with the second marginal cell not half as long as its petiole..... | <i>Uranotænia</i> |
| Wings with the second marginal cell more than half as long as its petiole | 3 |
| 3. Scutellum rounded—not lobed | <i>Anopheles</i> |
| Scutellum not rounded—distinctly trilobed | 4 |

* Contribution from the Entomological Laboratory of Harvard University, No. 337.

¹ This key was based on the list given by Johnson, 1925. Fauna of New England. 15, The Diptera or two-winged flies. Boston Soc. Nat. Hist. VII.

² 1922—The Mosquitoes of the United States. Proc. U. S. Nat. Mus. Vol. 62, Art. 1, pp. 1-119.

³ 1929—The Mosquitoes of North America. C. C. Thomas.

4. Cross veins tending to lie in line, or mesonotum with bare impressed discoloured lines or both....*Theobaldia*
 Cross veins normal, mesonotal integument without impressed discoloured lines 5
5. Abdomen of female blunt, with short cerci..... 6
 Abdomen of female pointed, cerci exerted 7
6. Wing scales normal*Culex*
 Wing scales distinctly large and broad.....*Mansonia*
7. Abdomen of female with the eighth segment wholly retractile, nude; spiracular bristles present
 *Psorophora*
 Abdomen of female with the eighth segment only partially retractile, spiracular bristles absent..*Aedes*

Larvæ

1. Eighth segment of abdomen provided with a distinct elongate dorsal siphon or respiratory tube 2
 Eighth segment without a distinct elongate dorsal siphon*Anopheles*
2. Anal segment without ventral brush*Wyeomyia*
 Anal segment with ventral brush 3
3. Air tube without pecten*Mansonia*
 Air tube with pecten 4
4. Air tube with several pairs of ventral tufts*Culex*
 Air tube with a single pair of tufts 5
5. Head elongate, elliptical*Uranotænia*
 Head nearly circular or transverse 6
6. Air tube with tufts close to base.....*Theobaldia*
 Air tube with tufts near the middle or beyond 7

7. Anal segment ringed by the dorsal plate, with hair tufts piercing the ring *Psorophora*

Anal segment not ringed by the dorsal plate or if ringed, the hair tufts posterior to the ring *Aedes*

TABLE TO SPECIES OF THEOBALDIA

Adults

1. Tarsi with faint whitish rings at both ends of joints *morsitans*

Tarsal white rings, if present, basal 2

2. Scales of the wings all black or brown, no white scales *impatiens*

Scales of the wings mixed, black or brown or white, especially along the costal margin *inornata*

Larvæ

1. Pecten of the air tube produced into long hairs on the outer half 2

Pecten not produced into long hairs on outer half *morsitans*

2. Both pairs of head hairs multiple (6) and of about equal length *impatiens*

Lower head hairs of three or four long hairs; upper multiple and shorter than the lower head hair *inornata*

TABLE TO SPECIES OF ANOPHELES

Adults

1. Wings with white or yellowish white spots along costal margin *punctipennis*

Wings without such marking 2

2. A bronzy or coppery spot at apex of wing *maculipennis*

- Apex of wing uniformly dark colored 3
3. Segments of palpi white scaled at apices.....*walkeri*
- Segments of palpi uniformly dark scaled
quadrимaculatus

Larvæ

1. Abdomen with six pairs of dorsal palmate tufts.. 2
- Abdomen with five pairs of dorsal palmate tufts.. 3
2. Mandibles with eleven terminal teeth; six branched hairs on mandibles arranged in an outward projecting row*quadrимaculatus*
- Mandibles with nine terminal teeth; ten branched hairs on mandibles, arranged in a forward projecting row*walkeri*
3. Lateral plate of the eighth abdominal segment with 22-29 (8 to 9 long) teeth*maculipennis*
- Lateral plate of the eighth abdominal segment with 17-22 (usually 6-7 long) teeth*punctipennis*

TABLE TO SPECIES OF CULEX

1. Abdominal segments transversely white banded apically*apicalis*
- Abdominal segments with white bands basally or none 2
2. Abdominal segments without basal white bands
salinarius
- Abdominal segments with basal white bands..... 3
3. Basal white band of the second abdominal segment usually not triangularly produced medianly
territans
- Basal white band of the second abdominal segment triangularly produced medianly*pipiens*

Larvæ

1. Antenna with the tuft at or before the middle *terrilians*
- Antenna with the tuft well beyond the middle 2
2. Both upper and lower head hairs multiple 3
- Both upper and lower head hairs not multiple *apicalis*
3. Air tube long and slender—7 x 1, slightly expanded before the apex *salinarius*
- Air tube not over 5 x 1, uniformly tapering toward the apex *pipiens*

TABLE TO SPECIES OF AEDES

Adults

1. Tarsi not white marked 2
- Tarsal joints or some of them white marked 12
2. Mesonotum with silvery or golden markings 3
- Mesonotum gray, brown, or golden yellow with a single median dark longitudinal band, two narrow lines, or unmarked 6
3. Mesonotum with two yellowish or yellowish silvery stripes on a dark ground *trivittatus*
- Mesonotum marked with silver, rarely absent 4
4. Silver in a broad or narrow line reaching scutellum or mesonotum entirely silvered (in the male) 5
- Silver on the sides of the mesonotum, the center dark *triseriatus*
5. Both sexes with a narrow silver stripe *atlanticus*
- Female with stripe, male mesonotum entirely silvery *dupreei*
6. Mesonotum with central broad undivided dark band 7
- Mesonotum with divided central band or none 9

15. Proboscis of the female white ringed 16
 Proboscis of the female without white ring 17
16. Abdomen with a longitudinal pale dorsal stripe *sollicitans*
 Abdomen without a dorsal stripe *tæniorhynchus*
17. Tarsal pale rings broad, especially on hind legs ... 18
 Tarsal pale rings narrow; mesonotum entirely brown 20
18. Wing scales broad, inflated *grossbecki*
 Wing scales narrow, normal 19
19. Large, without the red tint, mesonotum usually not whitish on the sides, wing scales dark; without mesepimeral bristles *excruciens*
 With 3-5 lower mesepimeral bristles *stimulans*
 Mesonotum often whitish on the sides, wings often with scattered white scales. 2 lower mesepimeral bristles *fitchii*
20. Terminal abdominal segments with normal pale brands *vexans*
 Terminal abdominal segments largely pale-scaled *cantator*

Larvæ

1. Air tube with tuft within pecten 2
 Air tube with tuft beyond pecten 3
2. Air tube with several dorsal hair tufts *trichurus*
 Air tube without several dorsal hair tufts *atropalpus*
3. Pecten with detached teeth outwardly 4
 Pecten without detached teeth outwardly 9
4. Air tube at least $3\frac{1}{2}$ times long as wide 5
 Air tube less than 3 times long as wide 6
5. Both pairs of dorsal head hairs multiple *cinerus*
 Both pairs of dorsal head hairs double *excruciens*

6. Antennæ enlarged basally*aurifer*
Antennæ not enlarged basally 7
7. Antenna as long as head*diantæus*
Antenna not as long as head 8
8. Lateral abdominal hairs single beyond second
intrudens
Lateral abdominal hairs multiple on 1st and 2nd, double 3-5*vexans*
9. Comb scales in a single row 10
Comb scales in a triangle 11
10. Anal segment ringed by plate*implacabilis*
Anal segment not ringed by plate*triseriatus*
11. Anal segment ringed by plate 12
Anal segment not ringed by plate 15
12. Upper and lower head hairs double*punctor*
Upper and lower head hairs single..... 13
13. Anal gills at least as long as anal segment...*trivattatus*
Anal gills shorter than anal segment 14
14. Lateral abdominal hairs double on 3-6.....*sollicitans*
Lateral abdominal hairs triple 3-5, single on 6
tæniorhynchus
15. Air tube at least 4 times as long as wide*fitchii*
Air tube 3 times or less as long as wide..... 16
16. Head hair single 17
Head hairs double or multiple..... 19
17. Anal gills at least as long as anal segment..... 18
Anal gills much shorter than anal segment.....*dorsalis*

18. Scale of comb with broad apex, 4-7 stout spines
communis
 Scale of comb with single stout spine *impiger*
19. Both pairs of dorsal head hairs multiple 20
 Both pairs of dorsal head hairs not multiple 21
20. Anal gills budlike *cantator*
 Anal gills well developed *canadensis*
21. Lower head hairs double—upper 3 *hirsuteron*
 Upper double—lower single *stimulans*

The following genera are each represented by a single species: *Mansonia perturbans*, *Uranotaenia sapphirina*, *Psorophora ciliata*, *Wyeomyia smithii*.

A large part of the study was restricted to the habits and biology of *A. sollicitans*. The eggs of this species are distributed over the salt marshes and during the summer months hatch when flooded by the waters of the tides and rains. The larvæ appear soon after the marshes are flooded and under favorable conditions develop in 7 to 12 days. Usually only the larvæ in the pools left by the peak tides (those most distant from the ocean, within 100 to 200 yards of the mainland)⁴ successfully complete their development since these pools are free from larva-eating fish and are not flushed by the succeeding lower tides. In a particularly dry season the water in many of the smaller pools along the edge of the marsh evaporates before the larvæ complete their development, thereby effecting a natural means of control. Pools formed by heavy rainfall are usually small and dry out rapidly and the larvæ are destroyed.

⁴This observation based on conditions existing along the North Shore, Massachusetts, in 1930.

Several chlorine determinations⁵ of water from pools containing larvæ of *A. sollicitans* were made. The results of these determinations indicate that the larvæ can live and develop in water having a chlorine content ranging from 400 to 2900 parts per 100,000 parts of water. Since the chlorine content of open sea water contained only 2000 parts, it is evident that larvæ can developed in water having a chlorine content greater than sea water as well as in water having a chlorine content considerably less than sea water.

Several evening collections of fresh water species were made in the Charles River Valley. The collections made in late May and early June yielded *A. cineris*, *A. excrucians* and *A. implacabilis* in about equal numbers. During July and August the collections contained a majority of *M. perturbans*. Of 120 specimens taken in one collection at Needham, Mass., in August, 118 were of this species, 1 of *A. punctipennis* and 1 of *C. pipiens*. *M. perturbans* is a difficult mosquito to control as the larvæ are not free swimming but attached to roots and stems of various aquatic plants. The adults are fierce biters but fortunately are weak flyers.

⁵ These determinations were made through the courtesy of the Massachusetts State Department of Health.

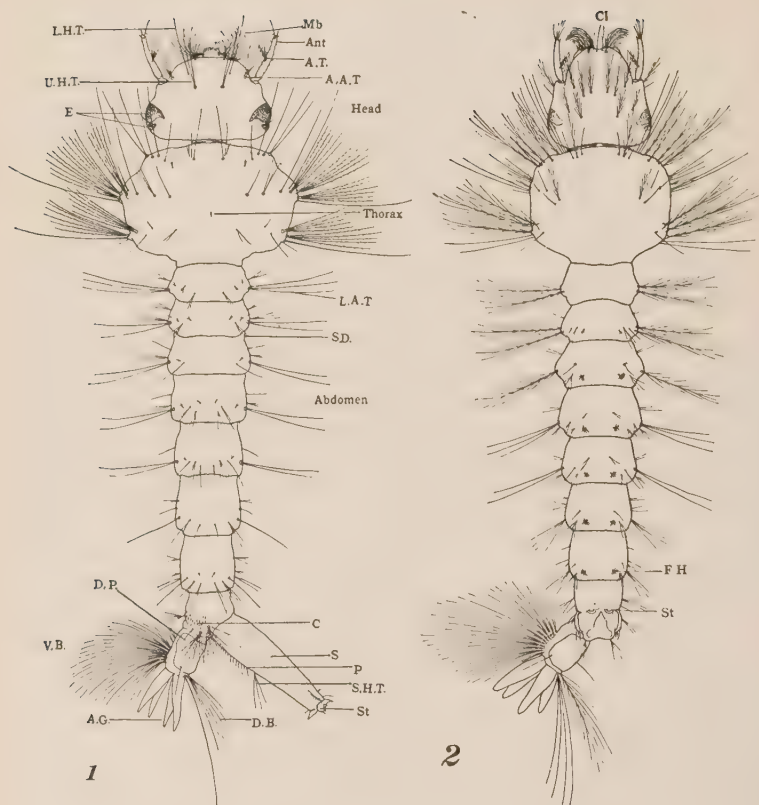


Fig. 1. Larva of *Aedes stimulans*.

Ant., antenna; A. T., antennal tuft; A. A. T., ante-antennal tuft; A. G., anal gills; C., comb; D. B., dorsal brush; D. P., dorsal plate; E., eye; L. A. T., lateral abdominal tufts; L. H. T., lower head tuft; Mb., mandible; P., pecten; S., siphon; S. D., subdorsal tuft; S. H. T., siphonal hair tuft; St., stigma; U. H. T., upper head tuft; V. B., ventral brush (after Matheson).

Fig. 2. Larva of *Anopheles punctipennis*.

Cl., clypeal hairs; F. H., float hairs; St., stigma (after Matheson).

THE INTERPRETATION OF THE WING VENATION
AND TRACHEATION OF THE ODONATA
AND AGNATHA.¹

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Translated, with an introductory note, by F. M. Carpenter.*

INTRODUCTION

In 1922 Dr. A. V. Martynov read a paper before the Entomological Society of Russia on the interpretation of the veins and tracheæ in the wings of the Odonata and Agnatha (Plecoptera). His manuscript was turned over for publication in 1923 and after some delay was finally published in Russian the following year (Rev. Russe Ent., 18(4):145-174). In connection with my investigations on fossil insects, I found it necessary to consult his paper, and from the very short French summary at the end of the article, I felt sure that the text contained important data and discussions which should not be overlooked. I therefore employed Miss Olga Jahr, of the Slavic Department of the Harvard Library, to assist me with the translation of the Russian. Naturally enough, Miss Jahr was unfamiliar with the biological terms, but by working together we obtained a complete English translation without much difficulty. As the translation progressed it became more and more evident that the text was fully as important

¹This paper is an enlargement of the report which was read at the Russian Entomological Society, November, 1922; the manuscript was handed to the press in May, 1923.

* National Research Fellow, Harvard University.

as I anticipated, and when the task was finished, I decided to publish the entire translation of this paper in order that it might be available to other investigators of insect phylogeny. Although there are several points on which I cannot agree with Dr. Martynov, I nevertheless consider this paper one of the outstanding contributions to insect phylogeny published during the past decade.

Dr. Martynov kindly assisted me in locating several misprints which occurred in the original text, and which had naturally caused me much confusion. The twelve figures accompanying the original article are essential for a complete understanding of the problems under discussion. Unfortunately, these figures were very poorly printed, and could not be copied for reproduction here without considerable retouching. Since there is always a possibility of distorting a figure during this process I decided that it would be better not to reprint the figures at all, but to refer the reader to the original ones. While this procedure, involving the use of two publications, may be somewhat inconvenient, I believe it introduces the lesser of two "evils."

—F. M. CARPENTER.

Comstock and Needham published (4) their first data on the interpretation of venation of the Odonata and Agnatha in a series of articles on the wings of insects, which appeared in 1898 and 1899; and in 1903 Needham developed (10) these ideas with more details into a large work on the venation of Odonata. The interpretation of Odonate venation which was proposed in both works mentioned above was later accepted by the majority of Odonatologists and by Handlirsch (6). According to this interpretation the nervuration of the Odonata proved to be so peculiar that it could hardly be compared even with that of the Agnatha—the very closest group.

The most characteristic features of this venational system are the following: 1, the crossing of the radial sector by the bases of M_1 and M_2 , and its extension into the region between M_2 and M_3 . 2, the large size of the media, with 4 branches; M_1 always leading from the base of M .

3, the curve of the cubitus (chiefly in the Anisoptera) and beyond this curve, the formation of the two branches, Cu_1 and Cu_2 ; formation of a triangle (or quadrilateral. 4, small size of the anal vein and its fusion with the cubitus.

It is necessary to add that according to the authors' understanding the continuation of RS to M_{1+2} is clearly a secondary vein ("bridge") and appears to be the basal part of the analogous vein indicated by Tillyard (14).

The venation of the Agnatha, as usually interpreted (Eaton, Comstock 1899, Handlirsch, Ulmer and others), is entirely different from that of the Odonata, and much more similar to that found in the more primitive Palæodictyoptera (Dictyoneuridæ). The media is simple and forks only in the distal part; RS is large and forms 4-5 branches; Cu is divided at the base, and the down curve is formed only by the lower branch; the anal veins are well developed. These differences in the interpretation of the wings of the Odonata and Agnatha are so great that the dragon-flies would on this basis be moved far off from the may-flies; but this contradicts the sum of all data in morphology and the development of these insects. If venation means anything in the explanation of phylogenetic relations of the different groups—as is unquestionably so, and the venation of the dragon-flies has been studied particularly carefully from this point of view—then either the evidence of morphology and history of development, which indicate a close relationship of the Odonata and Agnatha, are wrong; or the interpretation of the wing venation of Odonata or perhaps the Agnatha is incorrect. As the close relation between the Odonata and Agnatha is not disputed, the author began to doubt the accuracy of the usual interpretation of venation of the may-flies and partly of the dragon-flies.

It is well-known that Comstock and Needham based their interpretation of the wing venation in different groups on the study of the tracheation of the wings of nymphs and pupæ. This tracheation, it is supposed, reflects the more primitive condition of venation. The trachea RS of the Odonata (Anisoptera) turns off from R and, after crossing the bases of tracheæ M_1 and M_2 , enters the region between

M₂ and M₃; tracheæ which go into these latter veins and into M₄ of the authors, join at the base into one common trunk, which enters the wing independently. Hence the conclusion that this trunk is M, that RS crosses M₁ and M₂, that the bridge is a secondary formation, that the cubitus is two-branched, etc. Among the may-flies Comstock discovered at first a type of tracheation very different from that of the dragon-flies, and nearer to the normal. From this tracheation Comstock was led to an interpretation essentially similar (if not in names) to the one of Eaton (5) and other authors. Ann Morgan (8) undertook a careful investigation of the tracheation of different species of may-fly nymphs and discovered that the tracheal stem which sends small tracheæ into the branches of Comstock's RS usually arises independently from the common tracheal wing stem. Consequently, she concluded that the system of veins which include these tracheæ do not represent RS, but M, as in the Odonata. Usually in the may-flies the trachea RS does not arise from the trachea R, as it does in dragon-flies; but in one species of *Heptagenia*, and even then only in part of this specimen, Morgan succeeded in finding a weak trachea which led off from R, crossed M and entered into the region between M₁ and M₂. Following the ontogenetic method of Comstock, Morgan concluded that the may-flies also originally had the radial sector cross the media.

Comstock, in his later work on the wings of insects (3), which represents an enlarged and somewhat changed edition of the joint work of Comstock and Needham (4), agreed with the results of Morgan and accepted, therefore, her interpretation of the wing venation of may-flies. By this interpretation the venation of the may-flies was brought (to a certain degree) up to the scheme² of the venation of the dragon-flies; but by the same interpretation the Ephemerid venation appeared to be extremely remote from that of the Palæodictyoptera and even the Carboniferous *Triplosobidæ* Handl. Although the latter are placed in

² Only to a certain degree, because Rs of the may-flies in Morgan's paper is not this vein in the dragon-flies. In the latter Rs (of author's) corresponds to our Rs₁, and R₂ (Morgan and Comstock) of the may-flies corresponds to our Rs₃.

a special group by Handlirsch, *Protephemeroidea*, which combines the characteristic venational features of the more primitive *Dictyoneuridae* and the specialized features of may-flies, nevertheless they still are Ephemerids, which preserved only the anterior branch of M of the *Dictyoneuridae* (MA). As to the dragon-flies, Needham's interpretation aroused doubts only in its application to the *Zygoptera*. The trachea which supplies RS in the latter arises from M_2 , not from R, and in general no tracheae which lead from R enter into the region of M. But Comstock and Needham think that here also, the vein RS enters into the region between M_2 and M_3 , and that trachea RS used to arise from R and cross the media, but later "detached" itself from R and "attached" itself to M_2 . Since it is difficult to support the last supposition by definite proofs—there are none—Tillyard (15) and Rice (12) naturally expressed³ doubts about the *Zygoptera* having RS. Munz, however, pointed out (9) that the conformity of the vein veins of *Zygoptera* and *Anisoptera* is so evident that it is impossible to interpret the venation of *Zygoptera* different from that of the *Anisoptera*, and accepted the old scheme of Needham.

As I approached the study of the venation of dragon-flies and may-flies I thought that if the dragon-flies and Ephemerids were *Palæoptera*,⁴ i. e., insects which never fold their wings on the back (roof-like) at rest, then not only the may-flies but also the dragon-flies should preserve the features of venation of the related *Palæodictyoptera*. If the venation of dragon-flies, according to the interpretation of Comstock and Needham, proves to be so unusual that it puts them in an entirely isolated group among the insects, the cause of such a situation evidently lies in the wrong interpretation of the venation by these authors and the uncertainties of the ontogenetic method. It is necessary to note that at one time Redtenbach (11) offered an entirely different interpretation of the venation of dragon-flies; attaching great importance to the alternation of con-

³ Citing after Munz (9).

⁴ Concerning the division of the *Pterygota* into *Paleoptera* and *Neoptera*, see my paper (7).

cavities and convexities of the wing, the author compared their dispositions in dragon-flies and may-flies, and came to the conclusion that they are very similar in venation as well as in the alternation of concavities and convexities. Unfortunately this author, following the erroneous conception of Adolf (1) concerning the different origins of "convex" and "concave" veins in the first stage of the "fan" type of wing and the disappearance in other insects of a series of "concave" veins, came to an incorrect homologization of the veins of the two groups mentioned with those of other insects. Thus the cubitus of Ephemerids (and dragon-flies) he indicates by the number viii, which in other insects corresponds to A_1 ; the median by number vii, which corresponds to the cubitus, etc. Denouncing the earlier views of Adolf, Comstock and Needham also did not attach any importance to the similarity in the wing venation between the may-flies and dragon-flies, which was observed by Redtenbach.

It always seemed to me very risky to depend upon Comstock's and Needham's ontogenetic method for the explanation of the homology and evolution of venation. When we study the tracheation of nymphs and pupæ we study at the same time the ontogeny of tracheation, but not venation at all, because veins are vessel-like forms in which the blood circulates and into which nerves and usually tracheæ often enter; but there can exist veins without tracheæ. On the other hand, the thinner tracheæ which we observe in the nymphs and young imagines of dragon-flies and nymphs of may-flies go through the wing and outside of veins in great numbers and often do not connect the neighboring veins, but the ones lying far apart. As to the formation of veins, although it was previously supposed that they were formed originally by the tracheæ, more recent investigations have shown, especially in rather primitive groups [see, for example, the work of Marshall (17) on the development of the wings of the Trichoptera], that in the wing *anlage* the venation is formed before the tracheæ pierce through. Comstock and Needham supposed that the tracheation in the wing of a pupa and nymph reflects the primitive state of venation. Therefore one would suppose that in the forms with a venation which resembles

especially closely the scheme of the original venation, we should expect a particularly complete parallelism of the tracheation with the venation. But this is not so. In *Hydropsyche*, which is a small caddis-fly with extremely primitive venation, Comstock and Needham found a complete unconformity of the tracheation with the venation, which they interpret without regard for the direction of the trachea. These authors are obliged to do the same with the Hymenoptera and Diptera. Why should we rely so blindly upon the tracheation in case of dragon-flies and Ephemeroidea and ignore the data of paleontology, which proves the close relation of venation in contemporary representatives of dragon-flies and may-flies with that of the Palæodictyoptera (in the case of the Ephemeroidea, through the Carboniferous *Triplosoba* Handl.)? Such a "conception" is all the more unacceptable because the theory of Comstock and Needham encounters serious contradictions within the groups themselves. The crossing of the media which arises from R by means of the trachea RS takes place only in the Anisoptera; this does not appear in the Zygoptera, and the trachea of the corresponding vein arises from the branch M. We have no proofs that the latter condition developed from the former. As to the Anisozygoptera, in view of their very close relationship to the Agrionidæ (through the Lestinæ), one can suppose that in them the trachea RS of the authors arises from the media of the authors. A very diverse and changeable tracheation of nymphs of may-flies gives us still less right to conclude that they have such a crossing, that their complicated vein below R is M, etc.

My investigation of the relation of the venation to the tracheation has led me to the conclusion that the formation of venation occurred under the influence of causes of mechanical character; the tracheation, adapting itself to the newly formed distribution of veins, often changed in a most original way; therefore, one can judge the venation by such an "indirect" representation of it only with utmost care.

In view of these facts I decided that in investigating the venation of dragon-flies and may-flies, as well as of other groups, to turn first to the comparative study of the vena-

tion itself, at the same time constantly keeping in mind as much as possible the function of the venation, and changes which should appear in the phylogeny of the wing by the work of the separate parts of the wing and the work of its veins. Only after such investigation is it possible to approach the study of the history of tracheation, which depends upon the venation and reflects its history. This I will discuss at the end of this paper.

Let us first turn to the Palæodictyoptera. The "family" Dictyoneuridæ has the most primitive venation (figs. 1 and 2); the wings here are homonomous, hardly broadened at the base; sometimes their ends are somewhat pulled out and as if curved backwards (*Stenodictya*, *Microdictya*, *Stilbocrocis*, *Polioptenus*, et al). RS in the more primitive forms (*Stenodictya*, *Microdictya*) arises from R approximately at the middle of the wing, or a little nearer to the base; but in the majority of other forms we encounter the process of its receding towards the base. Usually RS sends 3 or 4 branches posteriorly, not counting its continuation; in some cases the second branch (counting from the base) does not reach the trunk RS, but adjoins to the first and sometimes (*Microdictya vaillanti*, *Stilbocrocis*, Eumecoptera) forks dichotomously. The media is divided into two branches, which we shall call M. anterior (MA) and M. posterior (MP)⁵; MA in this family, as well as in the majority of other Palæodictyoptera remains simple; MP branches in the Dictyoneuridæ, often forming three branches (*Stilbocrocis*, Eumecoptera, Dictyoneurula, Acanthodictyon, partly *Polioptenus*), in which it greatly reminds us of M in the Ephemerids. Normally the cubitus also divides not far from the base into two branches of which the first (anterior), CuA, usually remains simple as in *Polioptenus* and Eumecoptera (figs. 1 and 2); the posterior branch, CuP*, usually gives rise to smaller branches.

In the very primitive forms the anal veins form a comparatively homogeneous series of 3-4 veins, which gradu-

⁵ The development and configuration of the media have just the same characteristics as R. MA corresponds to the radius proper (R); MP, to the radial sector. The same was originally true of the cubitus (Cu).

* Misprinted MP in original.

ally grow smaller nearer to the base; but the more specialized A_1 is better developed, and others lose their independence, uniting either with A_2 or even together with A_1 .

There is no need to discuss the other families, because their wings were already specialized in different directions from those in which the dragon-flies and Ephemeroidea are specialized.

All recent Agnatha differ sharply from the Palæodictyoptera, in that their fore wings are greatly enlarged at the expense of the hind pair (fig. 4), which have become completely reduced in many species (in sub-group Bætoidea Ulm.). If the hind wings are present, the fore wings are wide and approximate a triangle; then, where the hind wings tend to disappear, the fore wings take the shape in the first group (Ephemeroidea and Heptagenioidea), which corresponds more to the shape of the fore and hind wings taken together.

If the hind wings of contemporary Ephemeroidea differ greatly from the fore wings, this was not the case in the past. In the Ephemeroidea of the Permian the hind wings differed very little or not at all from the fore pair, and their form resembled very much that of the wings of Dictyoneuridæ (13). Likewise, the wings of the remarkable Carboniferous Ephemeroidea *Triplosoba* Brogn. were homonomous (fig. 3). Handlirsch placed (6) this form into a special order, Protophemeroidea, because it preserved in its venation the features of the Palæodictyoptera, particularly of the Dictyoneuridæ. Just as in Eumecoptera (fig. 2) and in many other Dictyoneuridæ, RS arises nearer to the base and sends posteriorly the usual four branches, of which (and this is very important) the second branch, i. e. RS_4 , originates near RS_5 , and RS_3 and RS_2 , together with RS_1 , form the distal group. Evidently RS_2 , already forming the "inserted sector," did not reach RS_1 . M, as in the Dictyoneuridæ, is divided near the base into the same two branches, MA and MP; MA also, as in the Dictyoneuridæ, remains simple, while MP is divided distally into three branches, the middle one and the two supplementary ones beside it being already changed into "inserted sectors" (Schaltsectoren). The close similarity of this MP with M in the real Ephemeroidea leads us to believe that M of

the may-flies is really MP, and their MA is reduced and has completely vanished. Cu is divided into two simple branches, in which one can also see CuA and CuP of the Palæodictyoptera. Then come the anal veins; the long A_1 with its branches, and another long one, A_2 or A_3 , with its branches. The character of the cross-veins is the same as in Ephemerids. As already mentioned the fore and hind wings in the may-flies of the Permian were alike, their shapes quite resembling those of the Dictyoneurid wings; but in all that is known to us, MA was already missing. The branching of RS is also very much like that of Triplosoba and of the contemporary Ephemerids, while here also (Protecha Sell., Protoreisma Sell.) RS_4 arises near RS_5 , and the rest of the branches form the distal group. The branches RS_4 and RS_2 represent "inserted sectors" as in the recent Ephemerids.

According to the interpretation of Sellards and Handlirsch, Cu is divided into two branches at the very base; the anterior of these also divides into two side branchlets and a middle "inserted" one (in Protechma); and the posterior branch gives rise to two small branches directed posteriorly. The anal region is badly preserved. On account of this poorly preserved anal region it is difficult to say how to regard the two branches of the cubitus, whether they correspond to CuA and CuP of the Palæodictyoptera or whether there is another interpretation possible. Incidentally, the anterior branch with its branchlets is very much like the cubitus of Siphuridæ, Ecdyuridæ or Leptophlebiidæ.

The fore wings of the recent may-flies, because of the division of labor between the wings (all work of production of strokes and stroking the air being transferred to the fore wings), increased their dimensions and took the shape of elongate triangles, as in many Papilionidæ; as to the hind wings, where they are developed best of all—in Ephemeroidea and Heptagenioidea—they are of an oval or round shape as in many Rhopalocera, and in other may-flies—in Bætidæ, Ephemerellidæ, and Cænidæ—they are subject to greatest reduction. The fore wings, substituting in these groups for the disappearing hind ones, grow wider in the cubital and anal region and take a shape which

corresponds to the form of the fore plus hind wings in other groups, or to one wing of the homonomous group (Dictyoneuridæ, Carboniferous and Permian Ephemeroidea). Therefore, I think that the primitiveness of Bætoidea wings is only an apparent one and that in the past their fore wings were also probably of triangular shape. The differences in dimensions and in the shape of both pairs, in their turn also, were formed for a second time, replacing the original homonomous condition. The venation inherited from the ancestors was not effected by the change in the shape of the wings, and it remained very much like that of such may-flies of the Permian as *Protereisma*, *Protechma*, and also as *Triplosoba*. The homologizing of veins in these last forms with those in the Dictyoneuridæ is therefore not difficult and is correctly interpreted by Handlirsch. RS in *Triplosoba* also turned off (from R) at the very base, but here the place of origin (how, is another question) is still nearer to the base. But more often Rs is derived (secondarily) from the basal part of M.* The branching of RS is entirely similar to that of the Palæozoic may-flies and to that of the majority of Dictyoneuridæ, i. e., RS forms two groups: a basal branch, and another one almost always without a basal connection, the "inserted sector," Rs_4 ; and the distal one, including RS_3 , RS_2 , and RS_1 , the sector RS_2 having already lost its true origin ("Schaltsector"). In the hind wings, because of their reduction, the branches of RS are very seldom preserved, as in *Palingenia*; usually only RS_5 and RS_4 , and naturally RS_1 , are preserved, but RS_3 and RS_2 retreat towards the edge and are reduced. M corresponds to MP in the Triplosobidæ and Dictyoneuridæ, and forms the usual three branches. The branches of M in the hind wings are reduced also, and usually are simple (fig. 10). At the base of the fore wings, M approaches R almost to contact, and weakening, disappears; in the hind wings M often fuses at the base with R. Into this narrow path RS is directed and usually diverges from M, but often ends here as an "inserted sector," i. e., it weakens and disappears, being joined basally with R and M by means of the usual cross-veins. In the hind wings,

* Misprinted M_1 in original.

RS arises either from R or oftener from M. As well known, RS and M are tracheated in the may-flies in the majority of cases from one main trunk, which turns away from the side trachea (in the body), independently from R. This condition and perhaps also the fact that RS oftener "turns away" from M, gave Anne Morgan the motive to assert that the complicated vein which Comstock originally (4) indicated as RS, is actually M. We shall return below to the explanation of this moving off of RS from M, but now let us turn to the following veins.

Cu arises near M and soon divides into two main branches; Cu_1 and Cu_2 , with an inserted middle branch which joins at the base either to Cu_1 or Cu_2 ("inserted sector"). In all Ephemeroidea (Palingeniidae, Ephemeridae, Polymitarcidae, Potamantidae), Cu_2 forms a downward curve similar to the curve of the cubitus in dragon-flies. By means of its projecting angle, this curve approaches and often completely fuses with A_1 . The cross-veins disappear between the very origins of Cu_1 and Cu_2 ; on account of this, in my mind, they correspond morphologically as well as physiologically to the triangle of the dragon-flies (Anisoptera). In Heptagenoidea and Bætoidea this curve is absent (except in Bætisca, Oniscigaster), or it is expressed very faintly. The basal bifurcation and the general configuration of the origin of the cubitus in Ephemeroidea are certainly secondary if compared to, e. g., their condition in Dictyoneuridae. The condition in Siphuridae (and perhaps in the Ephemerids of the Permian) is therefore less changed.⁶ The peculiar condition in Ephemeroidea originated in the receding of the furcation point towards the base (this is a very common condition among the Palæodictyoptera, and in Ephemerids it unquestionably took place in RS), and by forming the curve in Cu_2 . This connection with A_1 , just as that in the dragon-flies, has unquestionably mechanical advantages, although the method itself and the original causes of the curve in Cu_2 are not clear to us. It is difficult to say yet if one can see in our Cu_1 and

⁶ However, it is possible that in some Siphonuridae the curve of Cu_2 was lost secondarily; the condition in Oniscigaster is especially suggestive of this.

Cu_2 of the Ephemeroidea CuA and CuP . The similarity with the dragon-flies seems to confirm it, but their palæontological data do not assert this with certainty, and I indicate these branches so far by different symbols.

In groups with the curve of Cu_2 present A_1 also has a more or less considerable curvature. Often the descending segment of Cu fuses entirely with the original of A_1 , a condition which we encounter in some Palingeniidae (Anagenesia, Plethogenesia), or otherwise disappears (Campsurus, Polymitarceus, et al). Ordinarily A_1 forms distally a series of branches directed posteriorly. It usually also has an upward curvature. A_2 arises either in the middle of A_1 and A_3 , or very close to A_1 ; usually it curves backwards soon after, and becomes short, and only in Bæticidae does it run parallel to the straight A_1 . A_3 is still shorter, but often has more branches; in Bætisca its first branch is parallel to A_2 . From the distal part of these (A_3) lead a few weak anal veins, but more often the latter lose their independence, and come in contact with A_3 in different ways.

In groups which have the tendency to a final reduction of the hind wings, the cubito-anal regions of the fore wings grow, take the place of the disappearing hind wings in function, and correspondingly elongate and distribute the anal branches in accordance with the mechanical needs (Cænidae, Bætidae, Leptophlebiidae). The anal veins preserve the more original bow-shaped form in the hind wings, but quickly weaken towards the base.

Now let us turn to the question of concave and convex veins, and to their relation to the veins in the wings of may-flies. In 1880 Adolf noted the fact that in the wings of may-flies the concave ones, like valleys, alternate with the convex, as longitudinal ridges. In the bottom of valleys and on the peaks of ridges are the adjoining longitudinal veins. Adolf regarded this alternation as very important. According to his understanding the "convex" and the "concave" veins have entirely different origins, significance and destinations. He thought that the original wings differed in the possession of a more regular alternation of the numerous convex and concave veins and that the wings

were similar to a fan. Redtenbach compared fully the distribution of these veins in the may-flies and dragon-flies, and found a complete correspondence. Later it was shown (2) that the indicated representation of Adolf was incorrect and perhaps this was the cause of Comstock's and Needham's paying little attention to the valuable comparisons of Redtenbach. The plaiting and alternative distribution of veins along the bottoms and tops has great mechanical value. The wings of the may-fly have attained a very high specialization. The membrane is extremely thin and delicate, and its veins have already adopted an extraordinary mechanical function and acquired the corresponding structure (ribs, absence of blood, dry structure) and their distribution also corresponds to the mechanical requirements. If this thin membrane were spread over the veins entirely in one plane, then at the stroke of the wings upon the air, being so delicate and unable to stretch, it would break and inevitably tear. The plaiting gives the membrane flexible, elastic qualities. At the sharp resistance of air on the stroke of the wings, the latter can stretch sufficiently because of the plaiting at all necessary points. In the formation of this plaiting the closely lying veins, as in similar cases (Arthropoda), were distributed, some on the bottom, others on top, and their course, even in their details, was affected by the plaiting; the fundamental character of the latter, in its turn, was conditioned by the original distribution of veins. In that way the continual reciprocal action of these two structures took place in the course of evolution. The concave position among the main veins includes Sc, RS, Cu and A₂, and then a series of distal branches, which alternate with the convex greater part of the distal sectors, Cuad⁷, Mad, RS₄, the RS₃ concave, RS₂ convex; among the smaller distal sectors, the larger ones also alternate. In the more primitive Palingeniidæ, Ephemeridæ, Ecdyuridæ and the ones near to them, which retain rich, thick venation in their wing, the greater part of the distal sectors, Cuad⁷, Mad, RS₄, the branches between RS₂ and RS₃ as well as these branches

⁷ Cu additional or M additional; in this way we shall designate the middle branches of Cu and M.

themselves weaken at their origin and appear to be tied to the neighboring veins only through common cross-veins; and already have no real basal part of their own, nor any origin. Such absence of the origin is unquestionably a secondary condition. In *Palingenia* and in some *Ephemera*, RS_4 arises normally from the trunk RS, but in others its origin disappears. The same seems to be the case with other sectors. In the specialized *Bætoidea* this process went still further, and in *Bætidae* all the longitudinal veins except the main ones (Sc, R,* RS,* RS_5 , M_1 , Cu_1 , A_1 , A_2 , A_3), lost their origins and became "independents," Woodworth (16) and the distal ones became shorter and shorter and deteriorated into a series of small veins along the edge, like the measurements on a ruler. How can one explain such a change? It can be satisfactorily explained through mechanical and practical means. The longitudinal veins lose their origins where they enter by means of their bases into the space between the branches of the forking vein, which forms a sharp angle, for example, RS or M. Such a vein is of course always "convex" if the dictomating one is concave, and vice versa. Because the part of support rests always upon the branching vein, the mechanical meaning of the basal part of the intervening vein diminishes and becomes insignificant; consequently the basal part of such a vein weakens, becomes thinner and disappears entirely. The economy of material requires the disappearance of the unnecessary part of the vein. Everyone knows that in the more specialized and (so to speak) "mechanized" wings, as those of the *Bætidae*, all superfluous veins disappear, and the remaining ones tend to keep the intervals between themselves equal. If the origins of the "inserted sectors" remained, this would be an injurious accumulation of veins in different places. The disappearance of the base also requires the alternative distribution of veins in different planes. If the vein is "concave," and the "inserted" vein, e. g., RS_4 , is "convex," then near the union with RS the short and weak part of the base would have a broken-up aspect (from the convex side to the concave). The mechanical meaning of this broken-up part is insignificant, therefore it

* Misprinted R_1 , RSc in original.

would unquestionably weaken and finally disappear. Such was, according to my understanding, the way in which the "inserted sectors" of the German authors were formed.⁸ Now, the origin of RS sometimes from M, more seldom from R, or its "free" origin becomes clear to us. Entering into the oblique angle between the convex R and M, the concave RS unquestionably had to become a "Schaltsector," which we quite often find in the typical species of Hexagenia, in some Siphylurus and others. The approach of the base of RS to one of the neighboring veins, e. g., to M, together with some small changes in the direction of the joining cross-vein (the cross-veins are certainly preserved) easily give the appearance that RS arose from M.

The appearance of the alternation of the convex and concave vein with its result—the change of convex veins into "inserted sectors"⁹—had been acquired by the ancestors of may-flies and dragon-flies very long ago. This appearance was well expressed not only in the may-flies of the Permian, but also in the Carboniferous Triplosobidæ, as becomes clear from their possession of a series of "inserted sectors." The dragon-flies of the Mesozoic do not differ in this respect from the recent ones. The Carboniferous "Protodonata," at least some of them, also acquired this alternation. The plaiting was already indicated in the Palæodictyoptera and Megasecoptera but it was very seldom that the branches actually turned into inserted sectors, and according to the branches we can judge with certainty about this

⁸ Woodworth, on the contrary, sees in the "independent" veins of the may-flies primitive structures which illustrate the process of the formation of the longitudinal veins of insects. The "independent" veins are supposed to receive their origins from the marginal vein, as growths of the latter to the inside; these growths are pulled out towards the base and finally fuse with one of the main trunks. The media, according to Woodworth, was formed as an independent vein also, only the anal veins having a different origin, and growing from the base. We have no need to stop to discuss this fantastic theory; it contradicts all data of paleontology and comparative systematics (the condition in Bætoidea is unquestionably secondary!), and is impossible from a morphological aspect. (One cannot imagine the growth of veins in the membrane.)

⁹ I do not exclude the possibility that some (short) intercalary veins of dragon-flies could develop as illustrated by Comstock (1918): as a result of the formation of plaiting.

plaiting. Such was the situation acquired, e. g., in *Camplyoptera eatoni* Brongn., a species referred by Handlirsch to the Megasecoptera. In the drawing by Handlirsch the character of the intercalary sectors is very clear. Furthermore, according to Handlirsch's drawing the change of some longitudinal veins into intercalary sectors had begun in *Lycocercus* and in *Epithethe*. In other Palæodictyoptera we do not notice this. In groups rich with longitudinal veins as the Spilapteridæ, Lamproptilidæ, Polycrægridæ, the plaiting was already suggested, but it never came to a formation of inserted sectors. The plaiting, together with the forming of inserted branches, is a very important mechanical improvement, which allowed lightening of the wing a great deal without loss of its firmness and elasticity.

Leaving aside for awhile the question of the origin of the peculiarities of tracheation in may-flies, which we will consider together with the tracheation of dragon-flies, let us turn to the venation of dragon-flies. The peculiarities of dragon-flies enumerated at the very beginning of this article, are, as stated, rather the peculiarities of interpretation, which result from the nature and insufficiency of the method employed ("method of ontogeny"), and not at all from the actual venation. Putting aside these hypothetical considerations, let us compare the wings of dragon-flies with those of may-flies and Palæodictyoptera.

First of all one should note that in form as well as in the general distribution of the main longitudinal veins and in the smaller reduction of the anal area, the Anisoptera show a great deal more primitive features than the Zygoptera, whose wings were subject to very great changes; one could say that in the Anisozygoptera everything in general is much closer to the Zygoptera, and as a matter of fact merges into them in their more primitive Liassic representatives (Archithemidæ, Heterophlebiidæ); they still partly resemble the Anisoptera in their form, configuration of the anal area, and in general distribution of the main veins.

In this collective Liassic complex the triangle (e. g., in Heterophlebiidæ) begins to take form, but further development was reserved only for such groups in which the triangle succeeded in acquiring its typical aspect,—and these were the groups that formed the Anisoptera; others, where

the "attempts" did not lead to the form of a typical triangle, died out. From here by way of another evolutionary path of the Zygoptera, were derived the majority of the known Anisozygoptera, which often cannot be told apart from the Zygoptera.

Unquestionable Zygoptera and Anisoptera are known only as far back as the Jurassic. The form of the wings in the Anisoptera and still more in the primitive Archithemidæ, resembles very much that of the wings of the Dictyoneuridæ, the most primitive of the Palæodictyoptera, also the Spilapteridæ, Triplosobidæ and may-flies of the Permian. If these dragon-flies have remained unchanged in their original form and homonomous nature of wings, we have also the right to expect a general plan of the distribution of veins, because the one and the other are bound together by function. This we actually find takes place. In Diastomma (Archithemidæ) no nodus is to be found and Sc has the same aspect and same relation to R as it has in the majority of Dictyoneuridæ and Spilapteridæ. The next longitudinal vein after R gives rise to 3 or 4 branches; their method of origin and general distribution repeats that in a series of Dictyoneuridæ and Spilapteridæ (e. g., in Stenodictya, Polioptenus, Acanthodictyon, Eumecoptera and others), and still more of Triplosoba and the Agnatha. The resemblance of the Triplosobidæ in the distribution of the branches of RS, especially to the Anisoptera, and to the recent may-flies is so striking and obvious, that we can compare vein by vein without difficulty. In the dragon-flies we usually find in the region of RS two groups, the basal, —formed by the *first* concave branch, as in may-flies ($RS_5 = M_3$ of authors); and the *second* convex and also usually "inserted" branch ($RS_4 = 1$ Morgan); and the distal group, formed by the concave RS_3 , the weak convex and sometimes almost disappearing inserted RS_2 , and lastly the concave continuation of RS (as in may-flies and Triplosoba). After this complicated RS follows the simple vein which is divided from it at the very arculus, and which is indicated by Odonatologists as M_4 , but which represents M. It is still impossible to say whether this M corresponds to MA or MP of Triplosoba, and that is why we shall indicate it simply by the letter M. At its base M turns sharply towards R

(as in may-flies) and almost fuses with it, but not entirely: by looking from above (partly), and in a cross-section the partition between the two veins is still distinct. The origin of RS from this turning-point of M, which sometimes has the form of a cross-vein, is not clear to us. RS arises here from the base of M just as in may-flies and one certainly should look upon such a manner of origin as a secondary appearance, even if this tendency was acquired very long ago, for it was already present in the dragon-flies of the Liassic and Jurassic. After this vein follows Cu (CuP) which forms in the Anisoptera and Anisozygota, soon after its origin, a more or less sharp curve or projection posteriorly, as in the suborder Ephemeroidea. This curve is still entirely distinct in the Agrionidæ, which appear to be the continuation of the Anisozygota, and disappears only in the species of Calopterygidæ (by the "straightening" of Cu and A).

Now, if we compare the relation of the longitudinal veins to the convexities and concavities in dragon-flies to that in may-flies, we will ascertain the identity of their distribution, which was well explained by Redtenbacher. This circumstance, certainly, proves once more the correctness of our comparison of RS in dragon-flies (=M of the authors) to RS in may-flies, etc. Cu (Cu+Cu₁ of the authors) is concave, as in the may-flies, and the next vein after it, which consists of the "anal bridge"+Cu₂ of the authors, forms the same kind of projection and is just as "convex" as in Ephemeroidea Ulm. This vein is unquestionably A₁, and Cu₁ of the authors is Cu₂, and to be even more exact, it is CuP. In the majority of the Anisoptera, A₁ comes into contact with Cu after the projection, but such contact, which often changes into fusion, is also frequent in the Ephemeroidea. On the other hand, in the majority of Zygota and Anisozygota and many other Anisoptera (compare Fig. 6, wing of fossil *Heterophlebia dislocata*, with Fig. 7, hind wing of *Phyllopetalia apicalis* Seyls), A₁ does not come in contact with Cu and runs independently and almost parallel to Cu. In its general appearance of A₁ (Cu₂ of the authors) of the dragon-flies, especially such as the Gomphidæ or Anisozygota, corresponds entirely to A₁ of may-flies, analogously forming an arch towards the front and analogously sending a

certain number of weak branches posteriorly. Next follows in the may-flies the concave A_2 , then the convex A_3 . But even if these veins did exist for a long time in the dragon-flies, they are fused now with A_1 at the base, and in the majority of cases this region has suffered great reduction. Usually we still find in the hind wings of the Libellulidæ two longitudinal veins, still quite distinct, which arise from A_1 . As we find the suggestion of a fusion of the two longitudinal veins with A_1 in the "Protodonata" also, the conception of the composite nature of A becomes possible.

We did not finish the investigation of Cu and the triangle. The triangle represents a frame which presses apart and at the same time strengthens Cu and M. The perfection of this frame in the Anisoptera evidently becomes an acquisition of importance and use in the mechanism of the wing. We find the formation of the triangle in the Archithemidæ and Heterophlebiidæ in *statu nascendi*. Its forms here were rather diverse, sometimes different in the fore and hind wings, and in general these triangles did not correspond entirely to the triangles of the Anisoptera. These groups with the aberrant triangle died out, and only the groups with the normal triangle were developed and became preserved up to the present time. In the series of Anisozygoptera-Zygoptera no triangle was formed, but in connection with this the original form of the wing is also not preserved, the venation, changed greatly in the anal area, became reduced, Sc became shorter, etc. But originally, as we notice in the Lestinæ and in the related Anisozygoptera, the distinct projection of Cu (and A_1) was here also. The same kind of projection is also clearly expressed in the very conservative group Ephemeroidea Ulm. The triangular area between the bases of Cu_2 and Cu_1 in the families of this suborder also closely resemble the triangle in the dragon-flies, only its external side in the former is represented not only by one straight vein, but by two cross-veins (between Cu_1 and Cuad, Cu_2 and Cuad), which are seldom placed opposite each other. The "inserted sector" Cuad is also often found in the Anisoptera; it is also well repre-

sented in the fossil *Heterophlebiidæ*¹⁰ by a longitudinal and usually uneven vein anterior of Cu. All these comparisons lead to the conclusion that in the dragon-flies, Cu₁ of the authors is not at all Cu₁, but that it corresponds to Cu₂ of the may-flies. Cu₁ of the may-flies does not exist any longer in the dragon-flies.* It is very possible that Cu₁ of the may-flies is CuA₁, but at present we cannot ascertain this.

The top side of the triangle was formed, according to Needham, by a cross-vein between Cu and M, slanting distally¹¹. This is contrary to certain facts. In *Neurothemis oculata* Fab., for instance, and even more in *Aeschnidium*, the region of the triangle, as well as other areas, is occupied by a thick net and between M from one side, and Cu and the top side of the triangle from the other side, is distributed a thick series of short cross-veins. It is absurd to attribute the formation of the upper side by an inclination of a cross-vein. The outside as well as the upper side very likely was crystalized, as it were, directly from the network (certainly of very fundamental origin) under pressure of mechanical causes. Furthermore, this vein exists in order to join the basal part of Cu with M. If it came into that position by the slanting of a cross-vein (between Cu and M) one would not understand how it could pass by M and terminate on the exterior side of the triangle, a short distance down from M; this condition one encounters sometimes in the *Libellulidæ* and we find it in *Heterophlebia*, where it goes to the exterior side and is almost parallel to M (hind wing, *H. dislocata*). Such diversity points to the diverse nature of the formation of this vein. As soon as this wing-structure, which was derived from the configuration of the venation and of the wing form and for the working of its parts, acquired the formation of a triangular frame, its two sides (the interior side is formed by the downward projec-

¹⁰ E. g., *Heterophlebia dislocata* (Handlirsch, l. cit., pl. 42, fig. 3).

¹¹ Needham, l. cit., p. 717, fig. 12.

* At the request of Dr. Martynov, the following sentences, which were in the original, have been omitted: "In the Protodonata (Meganura, Boltonites, Typidæ) we also usually find the simple anterior branch CuA₁, and the branch CuP joined to the anal group. This seems to point to the conclusion that Cu₂ of the dragon-flies is CuP, and that CuA disappears in them."

tion of Cu) begin to form themselves from the veins existing there, no matter which ones. It seems to be not an impossible idea that the upper side in some groups could be the remains of the original part of Cu₁. Cu₁, as in the may-flies, had to be concave, and this top side is concave, changing at the end into a sharply convex M. The fact that its end does not reach M would therefore be comprehensible. On this theory I do not insist because I cannot offer any definite facts of proof.

In the Zygoptera the true triangle does not exist, but in the Agrionidæ—and they form the main part of the Zygoptera—a structure was formed which in its function, to a certain degree, replaces the triangle. This is the “quadrilateral,” which hereafter takes the form of a narrow triangle. It is very certain that such a structure as it is represented in the Lestinæ, for instance, does exist, and is indicated by the fact that from the Anisozygoptera up to the present time only such a form as (*Epiophlebia suprestes* Selys) was preserved, where the “quadrilateral” has a form identical with that in the Lestinæ. Where the projection of Cu was not fixed by the formation at this place of the frame of a triangle, or quadrilateral of the type of Lestinæ, there the existence of this projection, and below the projection of A₁, lost its mechanical significance. More than that, this projection because of the functioning of this vein would be entirely without purpose and even harmful. It is not surprising, therefore, that in the Calopterygidæ, where the “quadrilateral” did not adopt the form as in the Lestinæ and *Epiophlebia*, Cu tended to straighten itself out in diverse ways; a tendency which reached its maximum development in Calopteryx and related forms.

Preceding the above discussion, I compared the venation of the dragon-flies with the venation of the Carboniferous *Protephemeroidea* (*Trilolsoba*) and through them to the Dictyoneuridæ. I referred little to the Protodonata because the evolution of their wings was along different lines from the dragon-flies. It is true that in part of them two branches of M are represented as well as the two branches of Cu, which do not exist in the Odonata; but in other respects they are more specialized and go further than the dragon-flies from such groups as the Dictyoneuridæ. One

can say that the primitive net of their wing was used for the formation of secondary longitudinal sectors, which imitate and take the position of the original ones. In contrast to what was as a rule expressed in the evolution of the Palæodictyoptera, may-flies, and dragon-flies, Rs did not expand, but decreased. In these the distribution of branches of RS and also M_1 and Cu is more pronounced than in the Odonata, and departs from the distribution which we find in the Dictyoneuridæ and Protephemeroidea. In this respect the Odonata have preserved more of the primitive features. The one-sided and extreme specialization of the wing venation of the Protodonata, with the loss of some fundamental features of their ancestors, were probably one of the main causes which brought about the rapid extinction of the group.

From the base of the Odonata there separated off, probably some time before the adoption of the main features of the recent venation, one more group known to us through a single representative from the Liassic—*Protomyrmelon brunonis* Geinitz. The wing venation of this form was figured by Handlirsch on Pl. 42, Fig. 14, and is reproduced here in Fig. 8. Some superficial resemblances with the Zygoptera, and at the same time some singularities of venation, lead the author to isolate the species in a separate sub-order, Archizygoptera. Sc is very much shortened and Rs and M very strongly distorted, so it is difficult to understand their distribution. Handlirsch represented Cu as two-branched; below it came the anal. If Cu is actually composed of two branches, then this fact, together with the peculiar structure of RS and M, would be sufficient for us to place this form into a separate order by itself. But one should note that the base of the wing is not well preserved in the fossil.

Now let us look briefly at the tracheation of the wings of the may-flies and dragon-flies. Such an inquiry is natural. If our interpretation of the venation of the dragon-flies and may-flies is correct, how can we explain, then, the way the trachea of RS runs in the anisoptera, where the trachea which arises from R is opposite the nodus, crosses RS_1 and RS_3 and enters into the vein RS_4 , extending, and often a great deal, from its base? How can we explain the almost regular

absence of the trachea in RS_4 of may-flies, and also of a series of distal branches chiefly convex, as in Agnatha, Odonata, etc? Let us try briefly to throw some light on the question; and let us start with the may-flies.

A characteristic feature of the tracheation of the *anlage* of the nymphal wing¹² appears to be its exceptional diversity in different groups and its marked instability, which is shown in a very great individual variation. By studying the tracheation in different groups and comparing it with the venation, we observe in the diversity a definite correlation with the peculiarities of venation. I base this statement upon the work of Morgan, who gave a series of illustrations of the tracheæ of nymphs of different may-flies, as well as on my observations. Only in some of the more primitive forms and then only in the early stages of the development of the wing *anlage*, do we encounter, as shown by Morgan, in Chironetetes, for example, the normal full tracheation, with the penetration of the tracheæ into all longitudinal veins through their bases. In the later stages of development of the same Chironetetes the part of the trachea which goes into RS_1 ($=M_1$ Morgan) disappeared and instead of this a series of small tracheæ was directed into the vein RS_1 from the neighboring, stronger trachea R. A quite full tracheation exists according to Morgan in Heptigenia sp. (P. 5, Fig. 3), but here the tracheation in RS_1 and also in some other small branches has already disappeared. I repeat, we seldom encounter normal tracheation. In most of the may-flies we usually encounter a regular alternating of veins in which the tracheæ normally penetrate through the bases with veins which have no such tracheæ, and which are tracheated by numerous small branches from tracheæ of the neighboring veins (see e. g., Fig. 11, which illustrates the course of tracheation as in species of Heptigenia Ulmer). Almost always the vein (with a few known exceptions in Chironetetes and Heptigenia) which is tracheated

¹² If the tracheoles are distinguished with difficulty in the wings of the imagines of dragon-flies, then it is still more difficult in the may-flies. However, the characteristic features of the venation and tracheation of the adults are already indicated in the nymphs, and for that reason we shall investigate the imagines instead of the nymphs.

by such means and which was one of the first to lose its own trachea, is RS_4 (=1 Morgan); that is the vein which has no normal tracheation in Odonata, where it receives the trachea either from RS_3 (Zygoptera) or from R (Anisoptera). Furthermore, the convex vein between RS_4 and RS_1 is tracheated (almost exclusively) in the same way. Tracheæ which go into M and R are often very weak also, or even vanish entirely (especially in M), and in such a way these veins adopt a secondary tracheation from the branches of the neighboring trunks. The intercalary vein in Cu_1 is similarly tracheated, sometimes A_1 also. If we compare such characteristics of tracheation with the characteristics of venation, then without effort we shall notice the fact that the first veins to lose their own trachea and begin to be tracheated by small branches from neighboring trunks are all veins which were made "inserted" (independent, intercalary, Shaltsectors, etc.),—that is, which lost their origins. Such veins as far as known are almost always convex veins. Furthermore, in the more primitive species groups as Bætoidea, but also Siphonuridæ and a few Ephemeridæ, the tracheæ which go into M and R, that is already into the main but exclusively convex veins, are weakened and eventually disappear. We have said above that because of this loss and even by the weakening, of trachea as in the case of R and M, which penetrate into the vein through the base, this vein begins to be tracheated by small branches from the neighboring tracheal lines. The tracheation of such "inserted" veins is, however, very diverse, because branches penetrate into it not only from neighboring systems but also from trunks which lie further away anteriorly and posteriorly. Such small branches must quite often go a long way around before they come into the necessary vein. Quite often some small tracheal branches, which are derived from the neighboring trunks as well as the trunks placed further away, become a great deal stronger than others, and accept the chief burden of tracheation; in such cases one or the other part, and sometimes most of the small tracheal branches, are subject to reduction. Finally, not rarely there are cases when only one trachea receives the repossession and tracheates almost entirely a given vein (a certain part of the

small branches or neighboring trunks nevertheless remain). The methods of tracheation, as it was noted above, are very diverse in general and subject in particular to a strong individual variation. The one or the other vein is tracheated sometimes only by small branches, sometimes also by larger ones. The latter penetrate either from the nearer or from the further lying trunks, etc. Evidently a series of causes not considered here (that is, certain circumstances), influence the distribution of smaller branches. Sometimes, however, the one or the other method of tracheation is understandable. In a number of forms, as noted, the trachea RS does not continue into the distal branch RS_1 , but turns off into RS_3 , and RS_1 is tracheated by small branches. This we will understand if we remember that alongside RS there runs the trachea trunk R, which can supply RS_1 with branches. However, when R disappears, the trachea RS_1 is usually preserved. Morgan, seeking for an analogy with the dragon-flies, noted that in one species of *Heptigenia* and only in part of these specimens, the tracheæ which supply RS_3 (=RS? Morgan) separate not only from the trunk RS, as usual, but also from R. Desiring to see in this the analogy with the Odonata, Morgan concluded that this vein is RS_1 , and that here we have a preservation of the crossing of the tracheæ and veins, which sometimes took place in the may-flies and now in dragon-flies.¹³ It is not necessary to say that such a conclusion, which is now supported by Comstock (3), has not enough foundation. In all may-flies the concave RS_3 is tracheated in a normal way from a concave trunk RS (=M₁ Morgan and Comstock), as it should be, and only in part of the specimens of *Heptigenia* studied the strongest trachea appears to be a branch of R. Taking into consideration the unusually great amount of variation in general, and the capriciousness of the tracheæ, can one attach such great significance to this exception, and conclude that this condition once existed in all may-flies, i. e., that in all may-flies RS takes root in the region of the media? Evidently such a con-

¹³ Only in the Anisoptera. Morgan says that the crossing was unquestionably present in the Zygoptera, but that is pure hypothesis which has no supporting facts and is more than doubtful.

clusion is very daring and was prompted by the wish to find a full analogy. However, Morgan is wrong in supposing that by such an interpretation a full analogy with the dragon-flies is established, because RS of the may-flies is a concave vein and corresponds completely to a concave vein in the dragon-flies, i. e., to RS_3 ; but not to the convex vein, RS_4 , which almost always has the character of a "Schaltsector," and which, according to the understanding of the authors is a branch of R_{∞} , i. e., RS. To this vein there entirely corresponds in the may-flies another convex vein, also always inserted, which Morgan indicated as I and Comstock as IRS (intercalary). If one attaches importance to such exceptional cases of the entering tracheal trunks, then we lose any support of the theory of the establishment of homology of the veins. According to the illustration of Morgan (Pl. 5, fig. 7) in *Epeorus humeralis*, the vein 1 is supported in the distal part by one trachea from M_2 . Why in such a case should we not consider vein 1 (that is, RS_4) to be only the branch of M_2 (that is, RS_5) and its basal part as a bridge? In *Blas-turus*, according to the same author (Pl. 6, fig. 27), the middle (interia) vein of the media is tracheated by one trachea which separates from RS_5 ($=M_2$ Morgan). Why not suppose that the crossing once existed here, and not consider that this vein is a branch of RS_5 , etc.? Such a supposition is not more unlikely than the one assumed by Morgan.

I have already noted above the fundamental nature of the relationship between the tracheation and the character of the venation. *Those veins which have lost the normal method of origin from other veins and become "inserted sectors," that is, after weakening at the base, have lost the base itself, those veins have lost the normal mode of tracheation and acquired a secondary tracheation.* Such veins are the convex branches and also some small secondary, distal, concave branches. It is true that not everywhere the convex vein-branches changed into "inserted sectors"; there are exceptions, though very seldom. Thus in *Palingenia*, RS_4 in the fore wings¹⁴ originates nor-

¹⁴ In the hind wing this vein is already a typical inserted sector.

mally and has not yet changed into a typically inserted sector. Nevertheless, here this vein takes a definite convex position and forms at its base a projection towards the concave vein R. This is sufficient for the secondary tracheation to be adopted. The main convex veins, R and M, had originally and have still in many species their own tracheal trunks, which penetrate into them; but in the other weaker tracheæ and in the more specialized groups, as in Bætoidea, for example, where the membrane is very fine, all superfluous veins are discarded and in the remaining ones the alternation of convexities and concavities is sharply expressed up to the very base, where the main convex veins, R and M, lose their own tracheæ.

The indicated relation becomes clear to us, if we look at it from an historical point of view. There was certainly once a time when the alternation of convex and concave veins was only suggested. There was still¹⁵ no inserted sectors, and the present convex RS_4 and RS_2 of recent types had a normal origin from R. Because of the absence of plaiting of the wings and the diversity in the methods of origin of the different veins receiving the trachea normally (that is, through the base from larger trachea of other veins of which they were branches), this position of the tracheation is approximately preserved at the present time, as mentioned above, in a great many primitive forms, and also in the earliest stages of development of the wing *anlage* in nymphs. As the wings "mechanized" more and more, that is, as the membrane became finer, the veins adopted an alternation of convex and concave positions, the basal part of the veins at the time of the change from the concave position (e. g., of R to RS_4) weakened and finally was obliterated. The normal tracheation through the base into the convex vein became more and more difficult, and then became impossible, when the vein

¹⁵ By this I do not mean to say that all, even the smallest irregular distal veins, were originally normal branches which arose from other veins. Small branches were formed at their places from the primitive network, were unstable, irregular, diverse and as a rule gave rise to no (secondary) alternation of convexities and concavities. Now, as before, they are tracheated by small branches probably in very diverse ways. These supplementary, secondary veins I do not consider here.

lost its base. This condition was carried over into the nymph, where in general there was at once laid down the foundation of imaginal venation. Such convex veins had to acquire a small tracheal supply by some other means. The small tracheoles in may-flies and dragon-flies (in nymphs and young imagines) frequently separate from the longitudinal trunks, and by means of the cross-veins usually reach the neighboring trunks. When the basal tracheal trunks began to weaken the small side branches of the neighboring trunks began to strengthen in their place, and finally to replace them completely in function. Because of causes which we cannot consider further, one or the other branches strengthened to the disadvantage of the others; and sometimes the tracheation, chiefly in one trachea which arose either from a neighboring or a remote trunk, appeared to be the most preferable. Since the strengthening of some of the small tracheæ depends upon a thousand small causes, because of their multitude and original similarity, even in the development of one individual, it is natural that the secondary tracheation had to be a very diverse and variable one. Under such conditions in the interpretation of the venation one should not attach any importance to the fact that in a certain species a vein receives its secondary tracheæ from neighboring trunks and not from the side where it should be. Such appears to me the origin of the secondary tracheation of may-flies; and if this idea is correct for the may-flies, then it is also correct and entirely applicable to the dragon-flies.

In dragon-flies the whole character of the tracheation of the wing in its relation to the venation maintains in general the same character as in the may-flies, since the dragon-flies have much less diversity and much more stability in tracheation than the may-flies. The tracheation of R is preserved everywhere, which is comprehensible to a certain degree if we consider the shortening of the subcosta in the dragon-flies. The tracheation of M is also preserved, although in the Zygoptera it is sometimes greatly weakened. The convex RS_2 , RS_4 and A_1 obtain a secondary tracheation by small branches from the neighboring tracheæ; the cross-tracheæ are of course supplied by the small supplementary distal, longitudinal veins. The media

in the Zygoptera is supplied by its own trachea as well as, to a greater or less extent, by the small branches of the neighboring veins. RS_2 , together with a series of other veins in the region of Rs and M , are supplied by small tracheoles (see fig. 9), but in Zygoptera the vein RS_4 is tracheated in this way at its basal part, while in its distal part usually (but with exceptions) by one fairly large branch which arises from RS_3 (fig. 9). In the Anisoptera, this same RS_4 receives its trachea from R_1 , and even the basal part of this vein (the "bridge") is tracheated chiefly by the branch of the tracheæ directed posteriorly. Comstock and Needham conclude from this fact that the vein RS_4 is actually RS , which takes root in the region of the media; and they extend this conclusion to the Zygoptera, in which this type of tracheation of RS_4 was never observed. From my historical point of view, such a tracheation of RS_4 , and in particular the difference in both suborders, becomes generally clear. The convex branches of RS and also A_1 for the same reasons as in may-flies lost their original and normal mode of receiving tracheæ and acquired a secondary tracheation at the expense of the ever-increasing small branches from the neighboring trunks, which used to enter here before. Such a method of tracheation was preserved in the basal part of RS_4 in Zygoptera, but in the greater distal half one trachea which separated from RS_3 became predominant. This acquisition of predominance by one or several branches in dragon-flies as well as in may-flies, is often found in the distal longitudinal veins, and there is nothing surprising that one of the tracheæ strengthens at the expense of the other in RS_4 . Originally, when the present-day type of tracheation was only beginning to evolve, the greater diversity probably took place here, as in the may-flies. Having lost its tracheation, RS_4 received at first the tracheoles from the neighboring trunks as well as from R , and in the same group some tracheal branches obtained predominance; and in other groups, other branches, etc. The tracheation of RS_4 in the Anisoptera from R was at last established (why, is another question); in Zygoptera, partly from RS and partly by the mere preservation of an earlier means of supply by small tracheoles (in the basal half). It is difficult to say why the tracheation of

RS₄ by the branch from R or RS₃ (almost) was established, but I think that the formation of a stable point of supply at the nodus had great influence upon the process of acquiring such a tracheation. In the Anisoptera the point of origin of the branch in RS₄ from the trachea R is just opposite the nodus. In the region of the nodus the wing is certainly stronger, is much less able to bend, and is much less exposed to occasional deformation at its distal point. The trachea which arises from this place in R is naturally more protected at its base and therefore more able to be strengthened and preserved than other more distally lying branches from the neighboring trunks. In the Zygoptera RS₄ is supplied by an entirely different trachea; this is from RS₃, but here also the place of origin of the trachea is opposite the nodus, though a little more distal. However, one should bear in mind that in the evolution of the Zygoptera, there took place migration of the nodus towards the base, so that the separation of the point of origin of RS₄ and the nodus becomes clear. The difference between these suborders in the tracheation of RS₄ proves my supposition about the original diversity and the probable variability of the growing secondary tracheation in the dragon-fly. It would be strange if in both suborders, which are so different on the basis of their venation, there should have been established a similarity of RS₄.

Unquestionably the tracheation is also secondary. This tracheation in general is similar in both suborders, but there are a few which are somewhat inconsistent. The tracheation of the wings of dragon-flies differs in general from that of the may-flies in its stability; but the stability is not so great as one would think and one encounters in the Anisoptera, a variation of even a serious character. I did not investigate these questions specifically; I shall mention only four young nymphs of *Æschna* sp., which were taken together in the fall of 1923 in a little pond near Lakhta; in one of these the tracheæ appeared to be anomalous in the following features: in the left fore wing the trachea R behind the nodus gives rise to a strong trunk, which at once separates again into three branches, entering into RS₄, RS₃ and RS₁. Only RS₅ is tracheated here from the trachea of the media. In the right hind

wing the trachea which supplies our $\tilde{M}$ (M_4 of the authors), appears to be free up to the very base, and arises only very near the trachea RS (fig. 12). The last variation is especially interesting as indicating that the origin of the trachea M from the general trunk Rs_4M is perhaps the result of a secondary fusion of the base of the trachea M with the base of RS.

And so the investigation of the tracheation of the wings of dragon-flies and may-flies from a functional and historical point of view leads us to the conclusion that the peculiarities were developed in connection with the acquisition of the characteristic features of these groups, the alternation of convex and concave veins, and usually the change of convex ones into "inserted sectors." Such features are characteristic of these two recent groups and the related fossils, Triblosoba, Protodonata (in part), some Megasecoptera and evidently some Palæodictyoptera.

The study of the relation of the jugal areas to the remaining part of the wing lead me in another work (7) to the conclusion that the *Insecta Pterygota* probably separated during the Lower Carboniferous into several branches which went along different lines of evolution, the Paleoptera (Palæodictyoptera, Megasecoptera, Agnatha, with their Carboniferous relatives) and the Neoptera (the remainder of the Pterygota, which at rest fold their wings roof-like over their abdomens). My study of the venation and the tracheation of the wings of may-flies and dragon-flies proves this conclusion, because according to the wings both these groups are similar in many ways to the Dictyoneuridæ, Triblosoba, and the typical members of the Paleoptera.

In conclusion, I would like to discuss one more question. How can one explain that out of the once rich and diverse group of Paleoptera, there are now existing only the Agnatha and the Odonata, the other groups having died out? I think that in a discussion of this question we should not forget the structure of such an important organ as the wing.

Of course the wings of recent dragon-flies are much more perfect than those of their remote ancestors, which were like the Dictyoneuridæ. They have lost most of those veins of their ancestors which were unnecessary from a

mechanical point of view (among the even the main branches of M and Cu); they have changed their form (may-flies) and have acquired (dragon-flies) such important mechanical structures as the triangle and the parts adjacent to it, that they have in general become greatly mechanized; but by this means we hardly can explain the persistence of these two groups, because the wings of many extinct groups had also attained that mechanical perfection, particularly the Megasecoptera, Protodonata, and many groups and families of the Palæodictyoptera. The Megasecoptera, as well as the other groups mentioned, advanced very far, but nevertheless died out early. Evidently all this explanation is insufficient and something else is needed. Comparing the wings of may-flies and dragon-flies with the wings of the most primitive forms, e. g., Dictyoneuridæ from one side, and from the other side the Megasecoptera, Protodonata and more specialized Palæodictyoptera, we find, between the one and the other, distinct differences. In the Megasecoptera the venation is so much reduced that their wings resemble those of the Dictyoneuridæ only slightly.

In the Protodonata the number of longitudinal veins, on the contrary, has increased greatly, but the relative dimensions of the systems of Rs, M and Cu, and the distribution of their branches have greatly departed from that which we have seen in the Dictyoneuridæ. Similar changes in dimension and distribution of branches are encountered in many Palæodictyoptera. Dragon-flies (especially Anisoptera) and may-flies, on the contrary, differ in that, disregarding the various specializations, they preserved the original relative dimensions of the systems of the main veins and the distribution of branches (especially Rs!). The Anisoptera preserved their primitive form of wing. Such preservation of the fundamental primitive features was the reason why the specialization of the wings of dragon-flies and may-flies did not become fatal for them, as in the case of the former groups. *A too rapid specialization, with the loss of the original primitive features, as we have in the Megasecoptera, Protodonata, etc., inevitably narrows greatly the potentiality of further evolutionary modifications, and leads such groups to an end of development and*

consequently to extinction.

And so this study of the venation of the two recent orders, the Agnatha and the Odonata, which to my mind represent the branches which separated early from the more primitive forms of the very similar Dictyoneuridæ, and which have nothing in common with the Neuroptera and Plectoptera¹⁶, leads me to the conclusion that such characteristic features of the venation and the distribution of veins (in particular RS, partly M) of the Dictyoneuridæ were preserved better in the dragon-flies and may-flies than in many Palæodictyoptera or Megasecoptera, in which the venation was too specialized or too reduced. May, 1923.

P. S. My work was already in the press of the Russian Entomological Review when the July number of *Psyche* (30:1923, nos. 3-4) appeared, with an article by Aug. Lameere on "The Wing Veins of Insects." In this small but very valuable article, the author discusses chiefly the venation of the Palæodictyoptera, the dragon-flies and the may-flies, and in many respects comes to the very same conclusion on the question of the interpretation of the venation as I have.

In the treatment of RS in the dragon-flies and the may-flies we agree perfectly, aside from terminology. According to Lameere, also, the media of may-flies corresponds to the posterior branch (our MP), in Triblosoba, etc., and the media of the dragon-flies according to the author is MA (my terminology). From a comparison of the Protodonata, I now entirely share this interpretation, according to which the dragon-flies lost MP. In the treatment of the cubitus we do not agree in everything, because the assertion of Lameere that the may-flies, as well as the dragon-flies, have lost CuA, is to my mind not entirely proven. I will not discuss here the venation of the other groups, and will note only that the conception of the author that there is a close relation between the Hemiptera and the Palæondictyoptera appears to me unlikely. According to my understanding of the venation of Eugeron, it is constructed entirely after the type of the Palæodictyoptera, and is far from the type

¹⁶ The Plecoptera have to be included according to my understanding into the super-order Orthopteroidea. A similar view has been taken by Lameere (1917).

of the Hemiptera. Eugereon, together with several other forms, represents only one on the branches of the Palæodictyoptera, and one can hardly connect it with the Hemiptera, which represents an entirely different trunk and must be referred to my group Neoptera; the latter separated very early from the division Paleoptera, to which one should assign Eugeron Dorhn. To all these questions I hope to return. Fall, 1924.

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EXPLANATION OF FIGURES

- Fig. 1. Wing (hind?) of *Polioptenus elegans* Goldenberg.
 - Fig. 2. Fore wing of *Eumecoptera laxa* Gold.
 - Fig. 3. Wing of *Triplosoba pulchella* Brongn.
 - Fig. 4. Wings of *Hexagenia bilineata* Say.
 - Fig. 5. Fore wing of *Gomphus descriptus*.
 - Fig. 6. Basal part of hind wing of *Heterophlebia dislocata* Brodie and Westw.
 - Fig. 7. Base of hind wing of *Phyllopetalia apicalis* Selys.
 - Fig. 8. Wing of *Protomyrmeleon brunonis* Geintz.
 - Fig. 9. Tracheation of wing of nymph of *Lestes rectangularis* Say.
 - Fig. 10. Hind wing of *Palingenia longicauda* Oliv., after Eaton (5).
 - Fig. 11. Tracheation of the *anlage* of the fore wing in the adult nymph of a member of the Hexagenioidea Ulm. (original).
 - Fig. 12. Anormalous tracheation in the hind wing *anlage* of a nymph of *Æschna* sp. (original).
- Figures 1, 2, 3, 6, and 8 after Handlirsch (6); Fig. 4 after Needham (8); Figs. 5, 7, and 9 after Needham (10).

ON THE VARIATION AND ABUNDANCE OF *SIREX*
NITIDUS HARRIS

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Dr. Frederic T. Lewis has obtained a large and interesting series of a horntail referable to *Sirex nitidus* Harris, at his summer place at Randolph, N. H. On July 29, 1930, Dr. Lewis sent me 18 males and 5 females; on August 3, 24 males and 25 females; on August 7, 9 males and 17 females; on August 10, 5 males and 4 females; on August 22 to 29, 6 males and 15 females; in all, 62 males and 68 females, a total of 130. Having but one male and three females of this species after twenty-six years collecting in New England, this large number came as a great surprise. The series is especially interesting in showing a remarkable range of variation. The smallest male measures 13 mm., the largest 25 mm., and the smallest female is 12 mm. and the largest 24 mm. This measurement does not include the ovipositor. Between the two extremes there is a complete gradation in size. There is also a great variation in the color of the two sexes, which together with the problem of distribution make the species of the genus *Sirex* difficult to define.

In determining this species there are many obstacles. It does not agree with *S. cyaneus* Fabr. as defined by either Bradley¹ or Waterston², but is closer to *S. noctilio* Fabr. as redescribed by Waterston. It differs, however, from that species in having all the femora of the male bright yellow not "darkened," the posterior tibiæ and the first three joints of the tarsi black. The female has the same form of cornus and length of ovipositor as *S. noctilio*, but

¹ J. C. Bradley, Journ. Ent. and Zool., vol. 5, p. 19, 1913.

² James Waterston, Bull. Ent. Research, vol. 5, p. 221, 1928.

the "tergites II-VIII" are not "dull black," but of a deep blue color, smooth and highly polished, as described by Harris³ under *Urocerus nitidus*.

The type came from Dublin, N. H., near Mt. Monadnock, about one hundred miles south of Randolph. It seems evident that this is the prevailing form of this region and that it represents the *S. nitidus* Harris. I have also received a male from Mr. Dwight Blaney, who collected it on Iron-bound Island near Bar Harbor, Maine. The males vary considerably in color. Three and often four of the basal segments and the eighth segment of the abdomen are dark blue. One has the base of the eighth only narrowly bluish, and a second specimen has the same segment with only a narrow apical margin of yellow. Many specimens have on the three or four yellow segments dorsal spots of blue, and the seventh segment is often widely margined with blue. As in *S. noctilio* the first transverse brachial vein may be either complete or incomplete, but this character is of little value. In 100 specimens, 60 had the vein complete and in 40 it was incomplete; in addition two specimens had the vein complete in one wing and incomplete in the other.

The specimens came from a Balsam fir (*Abies balsamea*) which had been cut down during the summer of 1929. On September 3 Dr. Lewis sent a section of the tree 11 inches long, with a diameter of $4\frac{3}{4}$ inches, from which 41 specimens had emerged. With the *Sirex nitidus* were taken three males of *Ibalia ensiger* Nort. This species like *I. maculipennis* Hald. is probably parasitic on *Sirex* and other wood borers.

While collecting on Nantucket, Mass., Sept. 9, 1929, I obtained an interesting specimen associated with *Sirex edwardsii*, a male in which all except the first and second segments of the abdomen are yellow. If the third and fourth joints of the antennæ were not reddish I should be inclined to refer it to *S. nigricornis* without question, and perhaps this may prove to be the case. All of the many male specimens of *S. edwardsii* taken have only the fifth and sixth segments of the abdomen yellow.

³T. W. Harris. Insects of Massachusetts Injurious to Vegetation, p. 391, 1841.

A BOT FLY FROM THE WHITE-FOOTED MOUSE

BY CHARLES W. JOHNSON

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In July, 1930, Dr. Langdon Frothingham presented to the collection of the Boston Society of Natural History a bot fly—*Cuterebra* (*Bogeria*) *fontinella* Clark, obtained from a White-footed Mouse (*Peromyscus leucopus noveboracensis* Fischer). The following note was furnished by Dr. Frothingham: "The larva of the bot fly, which formed a large swelling on the thigh of the mouse, left its host August 26, 1929, was placed in a small jar of damp earth, and almost immediately buried itself in the earth. It was left in my closed summer cottage at Pocasset over the winter. The earth was dampened twice in the fall, September and October, and again in June and July. The fly emerged on July 15, 1930."

The fly is 15 mm. in length and represents the smallest of our species of *Cuterebra*. It agrees in every respect with *C. fontinella* Clark as defined by E. E. Austin,¹ but not with *Bogeria fontinella* Clark as described by Townsend.² The standing of *Bogeria* even as a subgenus is questionable. The chief character, "arista bare," used by Austin having proved to be erroneous, Townsend took up a second character, "antennal pit," used by Austin to separate *Bogeria* from *Rogenhoferia*. This character when confined to *Cuterebra* has evidently no generic value.

This is the first record to my knowledge of this bot fly having been actually obtained from the White-footed Mouse, although the larvæ of *Cuterebra* have been found in this Mouse at Sandwich, Mass., by Willard Reed; at Wareham, Mass., by Outram Bangs; and at Bedford, Mass.,

¹ Annals and magazine of Nat. History, ser. 6, vol. 15, 1895.

² Insecutor Inscitiæ Menstruus, vol. 5, p. 27, 1919.

by J. Miller. Riley and Howard³ record *Cuterebra* larvæ from a mouse—*Sitomys californicus* at West Creek, California. Larvæ of this genus have also been found in the Meadow Mouse at Provincetown, Mass. I remember that while living in Florida I obtained *Cuterebra* larvæ from the large wood rat.

The life history of the *Cuterebrinæ* is quite different from the other subcutaneous bots. The flies appear from May to July and deposit their eggs, the larvæ maturing quite rapidly, leaving their hosts in August and September, and passing the winter in the ground as pupæ.

The abundance of bots on the Barren-ground Caribou (*Rangifer caribou* Gmelin) in Labrador is well illustrated by a skin recently tanned for Mr. Francis Richardson. A piece 7 x 10 inches presented to the Museum shows over 200 perforations, the number in the entire skin far exceeding 1000. About one-third of these entirely perforated the skin, the others represented scars of older perforations that had healed. Judging from the antlers the caribou was probably about eight years old. The bot fly in all probability is *Oedemagena tarandi* Linn., although a similar species *O. terrænovæ* Knab, is found in Newfoundland infesting *Rangifer terrænovæ* Bangs.

³ Insect Life, vol. 6, p. 47, 1893.

THE WALKING-STICK, *MONOMERA BLATCHLEYI*
RACE *ATLANTICA* DAVIS IN EASTERN
MASSACHUSETTS

BY CHARLES W. JOHNSON

Boston Society of Natural History

In 1926 I received from Mr. A. W. Higgins a female walking-stick, taken at Rock, Mass., August 10. It was referred to *Monomera blatchleyi* Caudell in the Bulletin of the Boston Society of Natural History for January, 1930, but should have been referred to the race *atlantica* Davis. As this was the most northeastern record for this interesting form, I was desirous of obtaining additional material and if possible securing a male. I therefore asked Mr. Higgins to be on the lookout for it this year.

The results of his work were a surprise. On August 10-15 he collected 19 specimens, on the 21st 40, and on the 27th 17, a total of 76 specimens, all females. I kept the 40 specimens alive for several days. On the 23rd there were 55 eggs in the glass jar, and on the 25th 57. The eggs, which look like little seeds, are 2.5 mm. long. Mr. Higgins found about 60 per cent of the specimens on goldenrod. Most of the specimens were a bright green, some having a more or less prominent yellow or reddish lateral stripe, two were of a dark grayish color, three were reddish brown, and two were laterally reddish, this color extending over the ventral surface except for a narrow median stripe of green. They vary in length from 65 to 80 mm.

The most interesting feature connected with this insect is the apparent absence of males. Mr. William T. Davis had some forty-six females when comparing this form with the typical *blatchleyi*, and many more have come under his observation. Are we dealing with a parthenogenetic species, the males appearing only at intervals?

NOTES ON AMERICAN NEMESTRINIDAE

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Most of the following notes have been in manuscript for a number of years, pending their inclusion in a revision of the American representatives of this family. The recent discovery of some of these flies in Yucatan prompts their publication in the present form.

Subfamily Nemestrinae

The subfamily Nemestrinae should, in my opinion, comprise all nemestrinids with an elongate, slender, hard proboscis, the labium usually provided with narrow labella. All the North and Central American species belong to one genus, *Neorhynchocephalus*.

Neorhynchocephalus Lichtwardt

Neorhynchocephalus Lichtwardt, 1909 (July), Deutsch. Ent. Zeitschr., p. 512 (based upon two species: *Rhynchocephalus sackeni* Williston, 1880, and *R. volaticus* Williston, 1883); 1910, *Loc. cit.*, p. 592.

Rhynchocephalus subgenus *Nemestrinopsis* Cockerell, 1910 (October), Bull. Amer. Mus. Nat. Hist., XXVIII, p. 285 (type by original designation: *Rhynchocephalus volaticus* Williston, 1883).

This genus, which is exclusively American, may be defined as follows:

Medium-sized flies, densely pilose, often with narrow hair-bands on the abdomen; the integument black, dark brown, or reddish yellow. Head broad and short, flattened

hemispherical. Face flattened or slightly concave. Frons flattened; linear or more or less narrowed beneath the ocellar triangle in the male (the eyes almost holoptic in certain species); very broad in the female, often occupying about one-third of the width of the head. Eyes bare. Proboscis elongate, stylet-like, slender, usually directed downward and backward, more rarely slanting forward; terminal labella long and slender, slightly flattened. Palpi short, very slender. Antennæ short; the two basal segments subequal, transverse; the third subcircular, flattened with a terminal, three-segmented, bare arista. Ovipositor of female long, sabre-shaped, composed of two slender, curved valves. Wing: alula broad; apical half never with a network of cross-veinlets; branches of third and fourth longitudinal veins long, running parallel with the hind margin; third and fourth veins never coalescing before the margin; first and second submarginal cells separated by a cross-vein (Cockerell's outer radio-medial); costa as a rule enclosing the hind margin of the wing completely and usually reached by the fifth longitudinal (or apical portion of diagonal vein), which thus divides the third and fifth posterior cells; base of fourth posterior cell removed from the anal cell and situated at or slightly beyond the lower basal corner of the discal cell; anterior cross-vein absent, the fourth longitudinal vein usually reaching the third some distance basad of the latter's branching.

Genotype, by present designation: *Rhynchocephalus volaticus* Williston, 1883.

Lichtwardt (1907, Zeitschr. Syst. Hym. Dipt., VII, p. 451) first pointed out that, in the genotype of *Rhynchocephalus* Fischer (*R. tauscheri* Fischer), the upper branch of the fifth longitudinal vein does not reach the hind margin of the wing. He later (1909) proposed a new genus, *Neorhynchocephalus*, for the Nearctic *R. sackeni* and *R. volaticus*, in which the hind margin is thickened into a vein, reached by the diagonal vein. *Neorhynchocephalus* was more fully characterized by Lichtwardt in 1910.¹ About the same time and quite independently from Lichtwardt, Cockerell also noticed that the diagonal vein extends to the hind margin in *R. volaticus*, while such is not the case in typical *Rhynchocephalus*. He therefore placed *R. volaticus* in a

new subgenus *Nemestrinopsis*. It would seem, however, that he wished to retain *R. sackeni* Williston and *R. subnitens* Cockerell in *Rhynchocephalus*, proper, although this is not clear from his paper.

The distinction between *Rhynchocephalus* and *Neorhynchocephalus* is entirely based upon two peculiarities of the venation. The first of these, *viz.*, the development of the costa along the hind margin and its connection with the diagonal vein, is probably too slight and variable to be of generic value. At any rate, in some of the specimens of *N. sackeni* which I have examined, certain stretches of the hind margin are not visibly thickened into a vein, and the margin is not fully reached by the diagonal vein, the third and fifth posterior cells being incompletely divided. The second feature, *viz.*, the contraction of the base of the fourth posterior cell, appears to be more reliable: it is present in 40 specimens of *Neorhynchocephalus*, belonging to the four known species. As a rule, the cell is briefly stalked at the base; but sometimes it is narrowly sessile on the second basal cell. I have seen only one specimen in which it was narrowly sessile on the anal cell, but even this condition is very different from that of *Rhynchocephalus tauscheri* Fischer, in which the base of the fourth posterior cell touches the anal cell over a long stretch, its lower margin running nearly parallel with the lower margin of the discal cell.

Contrary to Lichtwardt's statement, the shape of the frons in the male is not of generic significance. He writes that in *Neorhynchocephalus* the eyes touch each other on the vertex in the male; while the male of *Rhynchocephalus* has the eyes distinctly separated by the ocelli. In fact, the males of both genera have the eyes separated on the vertex itself by the ocellar triangle; below this the frons may be more or less narrowed. In *N. volaticus* and *N. sackeni* the frons is very much narrowed and linear, so that the eyes seem to touch each other. In two males of *N. vitripennis* (Wiedemann) the frons is moderately narrowed, the eyes being distinctly separated.

¹ The Zoological Record lists *Neorhynchocephalus* as dating from this 1910 paper; but the genus was validly established a year before.

Quite possibly *Neorhynchocephalus* should not be given generic rank, and rather be regarded as at most of subgeneric value. While it is not represented in the Old World, so far as we know, it does not contain all the New World species. Lichtwardt has described *Rhynchocephalus mendozanus* (1910, Deutsch. Ent. Zeitschr., p. 594; ♀ ♂), from Argentina, which he says has the venation of *R. tauscheri*, except "dass sich Cubitus und Media in einem Schnittpunkte trennen."

The four known species of *Neorhynchocephalus* may be separated as follows:

1. Two branches of fourth longitudinal vein united before the costa, the second posterior cell closed and with a long apical stalk. Black, with dense, rather short, pale yellowish pile; the abdomen not distinctly banded nor spotted. Length, 6 to 10 mm.... *N. sackeni* (Williston).

Two branches of fourth longitudinal vein ending freely in the costa, some distance from each other, the second posterior cell not stalked at the apex 2.

2. North and Central American species. Tibiæ and tarsi darker than the femora, especially those of the hind legs. Body covered with pale yellowish pile; the abdominal tergites with more or less distinct, white, apical fringes, and with small tufts of black hair on the sides; tergites often spotted with yellowish red. Frons linear in the male, the eyes nearly touching over some length below the ocellar triangle. Length, 8.5 to 14 mm.
..... *N. volaticus* (Williston).

South American species. Legs uniformly pale colored, dirty yellow to reddish-yellow. Abdominal tergites without distinct, white, apical fringes, but on the sides with more prominent tufts of hair, which are partly black.....3.

3. Head, thorax and legs densely covered with long bright sulphur-yellow pile. Wings distinctly infuscated at the extreme base. Length, 8 to 10 mm. (Male unknown to me) *N. sulphureus* (Wiedemann).

Head, thorax and legs covered with pale yellowish pile. Wings subhyaline throughout, at most slightly yellowish at the base. Male: frons narrowed beneath the ocelli, but the eyes separated by about half the basal width of the ocellar triangle. Length, 8 to 11 mm.
*N. vitripennis* (Wiedemann).

***Neorhynchocephalus volaticus* (Williston)**

Rhynchocephalus volaticus Williston, 1883, *Canad. Entom.*, XV, pp. 70 and 71, fig. 4 (♀; Florida); 1886, *Trans. Amer. Ent. Soc.*, XIII, p. 293 (♀); 1888, "Synopsis North American Diptera," p. 33, fig. C. W. Johnson, 1895, *Proc. Ac. Nat. Sci. Phila.*, XLVII, p. 325. Williston, 1901, "Biologia Centr.-Amer.," *Dipt.*, I, p. 269. Aldrich, 1905, "Cat. North Amer. Dipt.," p. 219. Cockerell, 1908, *Trans. Amer. Ent. Soc.*, XXXIV, p. 250. Williston, 1908, "Manual of North American Diptera," 3d Ed., p. 186, fig. 68. Kertész, 1909, "Cat. Dipt.," IV, p. 30.

Neorhynchocephalus volaticus Lichtwardt, 1909, *Deutsch. Ent. Zeitschr.*, p. 512; 1910, *Loc. cit.*, p. 593, fig. 2. C. W. Johnson, 1913, *Bull. Amer. Mus. Nat. Hist.*, XXXII, p. 54. F. M. Hull, 1923, *Ent. News*, XXXIV, p. 275 (♀ ♂).

Rhynchocephalus (*Nemestrinopsis*) *volaticus*, Cockerell, 1910, *Bull. Amer. Mus. Nat. Hist.*, XXVIII, pp. 285 and 286.

Rhynchocephalus species, Osten Sacken, 1886, "Biologia Centr.-Amer.," *Dipt.*, I, p. 73 (♀).

SPECIMENS EXAMINED.—Florida: one female (holotype) and two other females, without more definite locality (Riley Coll.—U. S. Nat. Mus.); St. Augustine, one male (C. W. Johnson Coll.); Georgiana, one female (Whitfeld Coll.—U. S. Nat. Mus.). Texas: one female and one male, without more definite locality; Cotula, one female, May 12, 1906 (J. C. Crawford Coll.—U. S. Nat. Mus.); two males, labelled "Neucest" (Marlatt Coll.—U. S. Nat. Mus.); Ray-

mondville, one female and one male (F. M. Hull Coll.). Mississippi: Agricultural College near Starkville, several females and males (E. K. Dickey, W. E. Anderson, and F. M. Hull Coll.). Kansas: Bourbon Co., 800 ft., one female (R. H. Beamer Coll.); Sumner Co., 1189 ft., one female (R. H. Beamer Coll.); Lawrence, one female (C. H. Curran Coll.); Douglas Co., one male (W. J. Brown Coll.). Mexico: Presidio River, Villa Union, Sinaloa, one female (A. Kusche Coll. U. S. Nat. Mus.3; Venodio [? Fenochio, Sinaloa], one female (A. Kusche Coll.—U. S. Nat. Mus.); State of Colima, one female (L. Conradt Coll.—U. S. Nat. Mus.); Mexico City, one female (Juan Muller Coll.—U. S. Nat. Mus.); Matamoros, Morelos, one female (W. L. Tower Coll.); Altamira Farms, four males (M. E. Hoag Coll.—Ac. N. Sci. Phila.). Yucatan: Chichen Itza, three females, and six males, taken in the dry forest, from June 6 to 10, 1929; the species is evidently common in this locality, although difficult to find and to collect; it is on the wing during the warmest and sunniest hours of the day, when it hovers in the bushes, some 2 to 10 ft. above the ground, poising on a spot for many minutes, while producing a characteristic, high-pitched noise; after a while it may rest on the tip of a dry branch.

There are also reliable, published records of *N. volaticus* from Kingsville, Texas; West Point, Mississippi; Chilpancingo, Guerrero; Mazatlan, Sinaloa; Vera Cruz, Mexico; and San Geronimo, Guatemala.

***Neorhynchocephalus sackeni* (Williston)**

Rhynchocephalus sackeni Williston, 1880, Trans. Conn. Ac. Sci., IV, 4, p. 243, fig. (♀; Olympia, Washington State); 1883, Canad. Entom., XV, pp. 70 and 71 (♂); 1894, Ent. News, V, p. 47. Snow, 1903, Kansas Univ. Sci. Bull., II, 5, p. 214. Hine, 1904, Canad. Entom., XXXVI, pp. 86 and 90. Aldrich, 1905, "Cat. North Amer. Dipt.," p. 219. Cockerell, 1908, Trans. Amer. Ent. Soc., XXXIV, p. 249, Pl. XVI, figs. 1 and 3. Kertész, 1909, "Cat. Dipt.," IV, p. 30. Cockerell, 1910, Bull. Amer. Mus. Nat. Hist., XXVIII, p. 286. Schaeffer, 1912, Jl.

New York Ent. Soc., XX, p. 296. Cole and Lovett, 1921, Proc. Calif. Ac. Sci., (4) XI, p. 239.

Neorhynchocephalus sackeni Lichtwardt, 1909, Deutsch. Ent. Zeitschr., p. 512; 1910, *Loc. cit.*, p. 593 (♀ ♂).

Rhynchocephalus clausus F. Brauer, 1883, "Offenes Schreiben als Antwort auf H. B. Osten-Sacken's 'Critical Review,'" Wien, p. 8. Not of Osten Sacken, 1877.

Rhynchocephalus subnitens Cockerell, 1908, Trans. Amer. Ent. Soc., XXXIV, p. 250 (♀; Clark Co., Kansas); 1910, Bull. Amer. Mus. Nat. Hist., XXVIII, p. 286. Schaeffer, 1912, Jl. New York Ent. Soc., XX, p. 296.

Neorhynchocephalus subnitens Lichtwardt, 1910, Deutsch. Ent. Zeitschr., p. 593.

SPECIMENS EXAMINED.—Southern Illinois, one female (C. Robertson Coll.—U. S. Nat. Mus.). Kansas: Clark Co., one female (F. H. Snow Coll.). New Mexico: West Canyon Camp, Koehler, one female and one male (W. R. Walton Coll.—U. S. Nat. Mus.). Arizona: Huachuca Mountains one male (C. Schaeffer Coll.). Colorado: one female and seven males, without more definite locality (U. S. Nat. Mus. and Zool. Inst. Halle a. S.); Fort Collins, one male (in Coll. Johnson). Utah: Mill Creek, one male (L. P. Rockwood Coll.); Salt Lake City, one female (E. C. Titus Coll.—M. C. Z. Cambridge). Idaho: Grangeville, one female (J. M. Aldrich Coll.); Whitebird, one male (J. M. Aldrich Coll.). California: Goose Lake, Medoc Co., one male (Holleman Coll.—U. S. Nat. Mus.). Oregon: Mt. Angel, one female and three males (F. Epper Coll.—U. S. Nat. Mus.); Forest Grove, one female (M. C. Lane Coll.); Lewisburg, one female (J. C. Chamberlin Coll.). Washington State: one female and one male, without more definite locality (H. K. Morrison Coll.—U. S. Nat. Mus.); Yakima River, two females (M. C. Z. Cambridge); Rock Lake, one female (U. S. Nat. Mus.). British Columbia: Vernon, one male (J. S. Hine Coll.).

There are reliable, published records of *N. sackeni* from Morton Co., Kansas; Colorado Springs, Colorado; Mary's Peak, Oregon; Corvallis, Oregon; and Union Co., Oregon.

Professor Cockerell informs me that two females and one male have been taken at Boulder, Colorado.

After examining a large number of *Neorhynchocephalus*, I am unable to regard any of the characters given for *subnitens* as of specific or even varietal value. Cockerell described *subnitens* as follows: "Smaller than *R. sackeni* Will.; length of wing just over 8 mm. (over $9\frac{1}{2}$ in *sackeni*); pubescence paler, with a sort of greenish gray tint; abdomen less hairy, the bases of segments 2-4 broadly exposed, shining black; ovipositor shorter, with a stronger, more even curvature; eyes apparently lighter and redder; ultimate branches of cubitus (bounding second posterior cell of Williston) uniting a very short distance before margin of wing (a considerable distance in *sackeni*)." The difference in the venation especially is unimportant, considering the variability exhibited by most species of Nemestrinidae. In the series of *N. sackeni* which I have studied, hardly two specimens are alike in this respect and often the right wing differs considerably from the left. For instance, the third submarginal cell may be petiolate at the base or broadly or narrowly connected with the first submarginal. In one female, from Salt Lake City, the left wing is fairly normal, but in the right wing the third submarginal cell is subdivided at about its basal quarter by a supplementary cross-vein. A somewhat similar abnormal division of the third submarginal cell in one wing is present in a female from Grangeville, Idaho, in a female from Forest Grove, Oregon, and in a male from Colorado; but the cross-vein is placed at a varying distance from the tip of the cell. A male from Colorado, in V. v. Röder's collection (Zoological Institute of the University at Halle a. S.), is even more aberrant: while the right wing is normal, in the left wing both the second and third submarginal cells are subdivided by cross-veins, placed a short distance from each other near the middle of the cells; in addition this left wing has a supplementary cross-vein about the middle of the fifth posterior cell, uniting the lower border of the fourth posterior cell with the hind margin. Cockerell also has figured the closed third submarginal cell of the right wing of a male from Colorado. The length of the apical stalk connecting the closed second posterior cell with the margin is very variable and

often different in both wings; in one case the cell being closed at the margin in the left wing and very short-petiolate in the right; at the base this cell may either touch the fifth posterior cell or be removed some distance above it. The fourth posterior cell is either stalked at the base, or sessile, or narrowly connected with the second basal cell. The anal cell is as a rule open on the hind margin; but in one male from the Huachuca Mountains, Arizona, it is distinctly closed. I may also add that in a letter, dated November 2, 1929, Professor Cockerell has expressed doubts as to the validity of his *R. subnitens*. He now thinks it may have been only a variation.

***Neorhynchocephalus sulphureus* (Wiedemann)**

Nemestrina sulphurea Wiedemann, 1830, "Aussereurop. Zweifl. Insekt.," II, p. 631 (no sex given; Minas Geraes, Brazil). Hunter, 1901, Trans. Amer. Ent. Soc., XXVII, p. 149.

Nemestrinus sulphureus Kertész, 1909, "Cat. Dipt.," IV, p. 25.

Neorhynchocephalus sulphureus Lichtwardt, 1910, Deutsch. Ent. Zeitschr., p. 594 (♀ ♂).

SPECIMENS EXAMINED.—Two females from northern Argentina: Mistol Paso near Icano, Chaco de Santiago del Estero (E. R. Wagner—Paris Museum).

Lichtwardt saw Wiedemann's types in the Vienna Museum and he says that they are male and female. He also studied three specimens of which he does not give the sex and the locality, in the Berlin Museum, and a female from Asuncion, Paraguay, in the Budapest Museum.

The two specimens from Argentina, though otherwise very similar, differ considerably in size; in one the wing is 8 mm. long; in the other 11 mm. The fourth posterior cell is short-stalked at the base in the larger one and very long-stalked in the smaller one.

***Neorhynchocephalus vitripennis* (Wiedemann)**

Nemestrina vitripennis Wiedemann, 1830, "Aussereurop. Zweifl. Insekt.," II, p. 631 (♀; Brazil).

Prosaeca vitripennis Schiner, 1868, "Novara Reise," Zool., II, Abt. vol. B, Dipt., p. 112. Kertész, 1909, "Cat. Dipt.," IV, p. 29.

Nemestrina vitreipennis Hunter, 1901, Trans. Amer. Ent. Soc., XXVII, p. 149.

Neorhynchocephalus vitripennis Lichtwardt, 1910, Deutsch. Ent. Zeitschr., p. 594 (♀).

SPECIMENS EXAMINED.—Two males. One, merely labelled "Bras.," in V. v. Röder's collection at the Zoological Institute of the University of Halle a. S., is a very old faded specimen, on a short pin, and may have been one of Wiedemann's cotypes. The other is labelled "Chapada," a locality in the southern part of the State of Matto Grosso, Brazil. This appears to be the first definite locality for the species. Lichtwardt only saw Wiedemann's cotypes at the Berlin and Vienna Museums.

Both males I have seen agree in having a well-developed, though narrowed frons below the ocellar triangles; their venation is practically identical. The specimen from Chapada is the larger, its wing being 10.5 mm. long; that of the other specimen measures 8.5 mm.

Subfamily **Hirmoneurinae**

The Hirmoneurinae should contain all nemestrinids with a well-developed, but short and broad proboscis, the labium ending in large, fleshy labella. The alula of the wing is always broad and the ovipositor of the female is telescope-shaped, consisting of several narrow segments capable of retraction within one another. In North America, this subfamily is represented by two genera, *Hirmoneura* Meigen and *Hymophlaeba* Rondani.

Hymophlaeba brevirostris (Macquart)

Hirmoneura brevirostris Macquart, 1845, Mém. Soc. Sci. Lille, (1844), p. 233, Pl. XX, figs. 1-1a; 1846, "Dipt. Exot.," Suppl. 1, p. 101, Pl. XX, figs. 1 and 1a (♂ ;

Merida). Osten Sacken, 1877, Bull. U. S. Geol. Geogr. Surv. Terr., III, p. 224; 1878, Smithson. Miscell. Coll., No. 270, p. 85. Williston, 1883, Canad. Entom., XV, p. 70. Aldrich, 1905, "Cat. North Amer. Dipt.," p. 218. Cockerell, 1908, Trans. Amer. Ent. Soc., XXXIV, pp. 251 and 252, Pl. XVI, fig. 2; 1910, Bull. Amer. Mus. Nat. Hist., XXVIII, p. 286.

Hermoneura brevirostris Kertész, 1909, "Cat. Dipt.," IV, p. 25.

Hymnophlaeba brevirostris Rondani, 1863, Arch. per la Zoologia, Modena, III, 1, p. 51. Lichtwardt, 1910, Deutsch. Ent. Zeitschr., pp. 580 and 591. J. Bequaert, 1920, Jl. New York Ent. Soc., XXVII, (1919), p. 306.

This species, originally described from the State of Yucatan, has been reported from Mexico by Lichtwardt. I have seen two specimens from Guatemala: El Rancho, one female (J. S. Hine Coll.), and Gualan (in the eastern part), one male (C. C. Dean Coll.—U. S. Nat. Mus.).

Since no adequate description of this insect has ever been given, the following notes may help to recognize it.

Female.—Integument of the body uniformly black, entirely covered with ashy gray pruinosity. Antennæ dark brown, the basal segments paler, the arista black. Proboscis and legs pale reddish-yellow, the tibiae dirty white. Body moderately hairy all over. Ocellar triangle and upper part of face with black pilosity; lower part of face and outer orbits with white hairs; two basal segments of antennae with very long and dense, spreading, black hairs, forming fringes above and below. Thorax densely covered with rather long, pure white hairs. Abdomen: first tergite with similar long white pilosity; the succeeding tergites evidently rubbed off in the specimen seen, since they bear only sparse, black and gray hairs, forming small tufts on the sides; sternites covered with silvery white pile. Legs with white hairs, mixed with a few black hairs on tibiae and tarsi. Head large, hemispherical in profile, about as broad as high, slightly wider than the thorax. Frons extremely narrow, less than one-quarter the width of an eye at its broadest point (just above the antennae); inner orbits diverging

both in the upper and lower portion, the frons being narrowest about midway between vertex and antennae, where the eyes are barely separated. Ocellar protuberance flattened, forming a much lengthened triangle, not distinctly separated by a groove from the inner orbits. Anterior ocellus about twice as far from the posterior ocelli as these are apart. Eyes very densely covered with long, gray pile. Antennae small, crowded together between the inner orbits; basal segment much longer than the second; third segment flattened, pear-shaped, a little larger than the second. Arista about the length of the combined second and third antennal segments. Body slender and narrow. Dorsum of thorax about as broad as long, the transverse suture distinctly marked on the sides, broadly interrupted in the middle. Scutellum semi-oval, cushion-shaped, with distinctly swollen posterior margin separated from the remainder of the scutellum by a slight groove. Abdomen elongate, oval, ending in an ovipositor composed of several gradually narrowed segments, capable of being telescoped into one another. Legs slender, the femora not swollen. Wing long and slender, slightly over three times as long as wide, a little shorter than the body and much longer than the abdomen; entirely hyaline. Costa distinctly developed along the entire hind margin of the wing and reached by the diagonal vein. The cross-vein separating the first and second submarginal cells reaches the third longitudinal beyond its branching. Three submarginal cells; the third briefly truncate at the base and closed at the apex, which is connected by a long stalk with the costa; the two branches of the third longitudinal vein fused over more than their apical quarter. Anal cell broadly open.

Length (to apex of tergite 4), 10.5 mm.; length of wing, 10 mm.; width of wing, 2.5 mm.

Male.—Differs little from the female, except in the usual sexual peculiarities. Eyes densely pilose, holoptic. In the specimen I have seen, the color of integument and pilosity and the venation of the wing were the same as in the female. The pilosity was, however, much better preserved, the entire abdomen being clothed, like the rest of the body, with long, whitish-gray hairs.



GEORGE DIMMOCK

Born May 17, 1852.

Died May 17, 1930.

George Dimmock, one of the founders of the Cambridge Entomological Club, died in his home town, Springfield, Mass., on his birthday at the age of 78 years. His interest in Natural History began early, and as a boy he made collections of insects and took part in the work of the local museum, of which he was curator in 1872, until he moved to Cambridge as a student at Harvard College, from which he was graduated in 1877. In 1879 he went to Germany and studied with Rudolph Leuckart at the University at Leipzig, from which he received the degree of Doctor of Philosophy. Later he went to Paris, where he studied with H. Lacaze-Duthiers at the zoological laboratory at Banyuls in Southern France. A paper on the mouth-parts of the Mosquito and other Diptera, part of his work at Leipzig, was privately printed in 1881.

Returning to this country, he settled in Cambridge, and took an active part in the work of the Entomological Club, being one of the editors of its journal, *Psyche*, from 1880 to 1890, at times taking entire charge and paying part of the expense of publication. Numerous short articles by him on various entomological subjects were published in *Psyche* at this time.

His entomological work began with the Coleoptera, and his principal work always was with this group. Short papers on the Coleoptera and Lepidoptera of the neighborhood of Springfield were privately printed from 1870 to 1873. Later he gave much attention to coleopterous larvæ, and a paper on this subject in connection with F. Knab, was published by the Springfield Museum in 1904. The specimens on which this paper was based were given to the National Museum at Washington. About this time he visited Cuba and made studies of the Cuban Coccinellidæ, which were published (in Spanish) by the Cuban Agricultural Station in 1906.

In 1890 his hearing began to fail and by 1900 he could hardly hear anything. By this time he became much interested in the history of the Dimmock family and in genealogy in general, to which he devoted much of his time, but continued to help in the entomological work of the Springfield Museum and among the Springfield teachers and school-children.

—J. H. EMERTON.



LOUIS WILLIAM SWETT

LOUIS WILLIAM SWETT

The friends of Louis W. Swett were greatly shocked to learn of his untimely death. He was killed by lightning at his summer home on Baker Island, Salem Harbor, Massachusetts, July 21, 1930.

Mr. Swett was born at Riverside, California, October 2, 1880, and came East with his parents when about ten years of age. He attended the Hopkinton School, Boston, where he prepared for Harvard, and was a student from 1900-1902.

I first met Mr. Swett in 1903, when he was interested in Lepidoptera as a whole, but later he specialized on the Geometridæ, describing many new species. He gave his first collection of Geometridæ to the Museum of Comparative Zoology at Harvard in 1912, when his business did not give him sufficient time to devote to it. Later, however, with his friend Mr. S. E. Cassino, he made a second collection, and jointly they published "The Lepidopterist." He was a member of the Boston Society of Natural History, the Cambridge Entomological Club, of which he was president in 1911, Pi Eta Society of Harvard, etc.

Mr. Swett was proprietor of a large dry goods store at Lexington, Mass., known as "The Modern Shop," and also had a store at Somerville, Mass. He is survived by his wife, daughter and mother, to whom we extend our sincere sympathy.

—C. W. JOHNSON.

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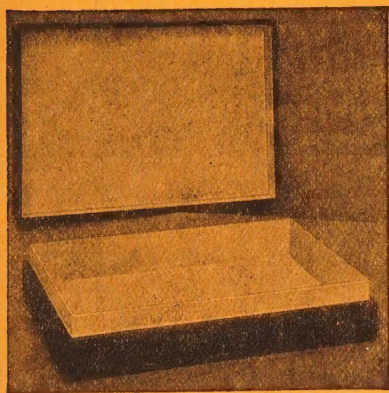
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